The

MEDICAL DEPARTMENT
OF THE UNITED STATES ARMY
IN THE WORLD WAR

VOLUME XI
SURGERY

PART TWO

EMPYEMA

By

LIEUT. COL. EDWARD K. DUNHAM, M. C.

MAXILLOFACIAL SURGERY

By

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and
MAJOR JOSEPH D. EBY, D. O. R. C.

OPHTHALMOLOGY
(United States)

By

BRIG. GEN. GEORGE E. DE SCHWEINITZ, M. O. R. C.

OPHTHALMOLOGY
(American Expeditionary Forces)

By

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OTOLARYNGOLOGY
(United States)

By

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OTOLARYNGOLOGY
(American Expeditionary Forces)

By

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LETTER OF TRANSMISSION.

I have the honor to submit herewith a portion of the history of the MEDICAL DEPARTMENT OF THE UNITED STATES ARMY IN THE WORLD WAR. The portion submitted is Part Two of Volume XI, on the subject of SURGERY, and includes Empyema; Maxillofacial Surgery; Ophthalmology in the United States; Ophthalmology in the American Expeditionary Forces; Otolaryngology in the United States, and Otolaryngology in the American Expeditionary Forces.

MERRITTE W. IRELAND,
Surgeon General, United States Army.

The SECRETARY OF WAR.

[a] The highest rank held during the World War has been used in the case of each officer.

PREFACE.[a]

In the expansion of the Office of the Surgeon General to meet the demands imposed upon the Medical Department by the World War, special divisions, with various subdivisions or sections, were created for the conduct of given activities. An important part of the work of one of these, the Division of General Surgery, was devoted to the study of infections of the pleural cavity following influenza and pneumonia, commonly designated as empyema. In the first tentative outline of the history of the Medical Department a complete volume was apportioned to the report of this study. It was found impracticable, however, to follow this plan, and "Empyema" has been given place with other subjects. Likewise, it was originally intended to devote a complete volume to the professional activities of the Division of Head Surgery, which included in its functions the supervision of all professional work pertaining to brain, spinal cord, and peripheral nerve injuries; maxillofacial surgery; ophthalmology, and otolarnygology. The narration of the surgical activities relating to injuries of the brain, spinal cord, and peripheral nerves will probably require an entire volume. Following the plan of issuing the parts of the history as they are ready for the printer, the remaining subjects embraced in "Head Surgery" are incorporated with "Empyema" to form this part of the volume on general surgery.

The section on empyema is an amplification of work which was started by the empyema commission early in 1918. The empyema commission, in turn, was the outgrowth of a pneumonia commission. During the second half of the year 1917, pneumonia, in part secondary to measles, in part primary, was causing approximately 65 per cent of all deaths in the Army in the United States. Prompted by the necessity of devising some means to combat this terrible loss of life, the Surgeon General appointed a commission to study pneumonia in its clinical, bacteriological, and pathological aspects. He sent the commission to Texas in February, 1918. One of the far-reaching results of the work of this commission was the determination that the *Streptococcus hemolyticus* was playing the principal rôle as a causative agency in many of the cases of pneumonia, giving rise to an entity which the commission termed "interstitial bronchopneumonia."

Because empyema constituted such an important complication of pneumonia, more especially in cases of pneumonia associated with the *Streptococcus hemolyticus*, the Surgeon General created another commission, the latter to take up research work where the Texas commission left off.

In the early spring of 1918, this commission, afterwards known as the empyema commission, was sent to Camp Lee, Va., to study empyema. The qualifications of the members of the new commission were adequately diversified to enable them to study the cases from bacteriological, surgical, and nutritional

[a] For the purpose of the History of the Medical Department of the United States Army in the World War, the period of war activities extends from April 6, 1917, to December 31, 1919. In the professional volumes, however, in which are recorded the medical and surgical aspects of the conflict, as applied to the actual care of the sick and wounded, this period is extended, in some instances, to the time of the completion of the history of the given service. In this way only can the results be followed to their logical conclusion.

standpoints. At the head of this commission was Lieut. Col. Edward K. Dunham, M. C., who had previously gained international reputation for constructive work of high merit in bacteriology. Colonel Dunham immediately directed the efforts of the commission, so long as it existed, and after the war gave nearly three years of unremitting and devoted labor to the compilation of the valuable data which he embodied in the manuscript on empyema. This work Colonel Dunham had all but completed, when, suddenly stricken at his home on April 15, 1922, he died, and a life of exceptional usefulness to science and his country ended.

Acknowledgment is made to Lieut. Franklin A. Stevens, M. C., for the large part he played in the preparation of the empyema manuscript, in association with Colonel Dunham.

The chapter on the surgical treatment of the acute and chronic stages of empyema was prepared by Maj. Evarts A. Graham, M. C. Major Graham was an original and permanent member of the empyema commission, Camp Lee, Va., during the World War, and the work in question represents the result of his experimental efforts in the surgical treatment of empyema.

Chapter VIII, the surgical treatment of the refractory empyema cavities, was prepared by Col. William L. Keller, M. C., and is an exposition of his revolutionary surgical work on a series of what had been previously considered almost hopeless cases.

The section on maxillofacial surgery was edited by Lieut. Col. Robert H. Ivy, M. C., and Maj. Joseph D. Eby, D. C. During the war, Colonel Ivy was local consultant in maxillofacial surgery, Vichy and Clermont Ferrand hospital centers, France; assistant to chief of Section of Plastic and Oral Surgery, Surgeon General's Office; consultant and chief of maxillofacial service, Walter Reed General Hospital, Washington, D. C. Major Eby was on duty at Walter Reed General Hospital, Washington, D. C. In a footnote to the introduction to the maxillofacial section, page 393, will be found the names of officers of the Medical Corps whose contributions in the way of reports, illustrations, etc., were utilized in the preparation of the section.

Brig. Gen. George E. de Schweinitz, M. O. R. C., editor of the section on ophthalmology in the United States, was chief of the ophthalmological section of the Division of Head Surgery in the Office of the Surgeon General, and had full direction of the ophthalmological service at home.

Col. Allan Greenwood, M. C., and Col. James F. McKernon, M. C., editors, respectively, of ophthalmology and otolaryngology, A. E. F., were chief consultants of the American Expeditionary Forces and conducted the work of these specialties in our Army abroad.

Unfortunately, it was impossible to secure a compilation of the data on otolaryngology in the United States from any of the officers connected with that service. This part of the history was prepared by Lieut. Col. S. J. Morris, M. C., in the Historical Division.

In the preparation of the different sections of this part of the volume on general surgery, reports and published articles contributed by officers of the Medical Corps on duty at the various camps, posts, hospitals, and ports of embarkation have been used extensively. It was intended that acknowledgment be made to each of these officers for the valuable service so rendered, yet in some instances proper credit may have been omitted; this was entirely unintentional and due acknowledgment is here made.

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SECTION I.

EMPYEMA.

INTRODUCTION.

As an introduction to the following study of empyema among the troops of the United States Army on this side of the Atlantic, it is deemed proper to describe the sources of information upon which this study is based.

In the vast majority of instances empyema developed as a complication or incidence in the course of some other affection, and the patient was admitted to hospital treatment because of the primary disease. This primary condition may have been pneumonia, measles, or some other exanthematous disease, tonsillitis, pharyngitis, influenza, or even such a remotely related condition as articular rheumatism, malaria, otitis media, appendicitis, hernia, or a host of others that need not be enumerated.

The fact that empyema is most often a complicating or associated disease has made it impossible to discover all the cases that occurred in the Army; and there must have been some that entirely escaped detection during the whole stay in hospital. It is not possible to estimate the total number of such omissions, but it is certain that they were most numerous among cases that remained, throughout their stay, in the wards of the medical service. Cases admitted to the surgical wards, by transfer from the medical service, were received as empyemata and entered as such upon the records and in the index of diseases. Here omissions in the reports of cases are insignificant in number.

Another aspect of empyema seriously complicated the problem of collecting data. Cases seemingly cured were liable to relapses, not infrequently after a period of apparent good health. It was essential to know about such cases. It was also important to gain information concerning the final disabilities of men who had empyema during their military service, not only while they were in the Army, but after they had returned to civil life. It is obvious that the routine records of the Medical Department of the Army could not supply all of this necessary information. Supplementary data had to be obtained through other than the regularly established military channels. Chapter I is devoted to an account of the manner in which this was attempted, and the way in which the records were assembled for study.

CHAPTER I.

THE COLLECTION AND UTILIZATION OF SPECIAL DATA CONCERNING EMPYEMA IN THE ARMY WITHIN THE UNITED STATES.

THE COLLECTION OF DATA.

Questionnaire on empyema.—The receipt of reports indicating a marked increase in the number and severity of cases of empyema in base hospitals, not infrequently subsequent to measles, led to a questionnaire which was issued by the Surgeon General of the Army on February 21, 1918. This questionnaire was designed to secure particulars concerning this disease, the measures that were being taken to limit its occurrence and those that were employed in caring for cases. The letter of instruction accompanying the questionnaire, and the questionnaire, are quoted in full:[1]

FEBRUARY 21, 1918.

From: The Surgeon General, U. S. Army.
To: The Commanding Officer, Base Hospital (through Division Surgeon).
Subject: Questionnaire on empyema.

1. A consolidated report of the chiefs of surgical service, medical service, and pathological service, should be rendered on the inclosed questionnaire at the earliest possible date, to this office, attention Lieut. Col. W. H. Moncrief.

By direction of the Surgeon General.

(Signed.) WM. H. MONCRIEF,
Lieut. Col., Medical Corps.

QUESTIONNAIRE CONCERNING EMPYEMA.

1. In the measles cases what prophylactic therapy is applied to the upper air passages (nasal cavities and accessory sinuses)?
2. What measures have been taken to isolate and quarantine empyema patients?
3. Has the X ray been used in diagnosis systematically and repeatedly?
4. What percentage of pneumonias developed empyema? (*a*) Lobar pneumonia; (*b*) pneumonia (broncho- or lobar) following measles?
5. What organisms have been found in pleural fluids in order of their frequency?
6. Have blood cultures been made systematically and repeatedly?
7. What did the blood cultures show?
8. Has the administration of antistreptococcus serum been part of the treatment?
9. If so, what methods of administration have been used?
10. In your opinion has this treatment had any beneficial effect on the progress of the disease?
11. Is immediate operation advisable?
12. Thoracotomy or thoracostomy and costectomy?
13. General or local anesthesia?
14. Do you prefer early aspiration of the chest, followed by operation after the pus has become thick?
15. Has Dakin's or any other solution been used for irrigation in patients operated upon?
16. If so, with what result?
17. Has continuous negative pressure been used post-operatively and with what results?
18. What has been the mortality in empyema? Divide into types if possible.
19. What percentage of empyema cases have been operated upon?
20. What percentage of empyema cases is followed by—
    - (*a*) Empyema of opposite side?
    - (*b*) Purulent pericarditis?
    - (*c*) General peritonitis?
    - (*d*) Pneumonia of opposite side?
    - (*e*) Sinus involvement.
    - (*f*) Meningitis?
21. At autopsy are pockets of pus found, particularly substernal or just internal to and behind the anterior flap of the lung?
22. Furnish other important autopsy findings.

A consideration of the replies to this questionnaire is deferred to the section on epidemiology.

Circular Letter No. 23.—While in some instances empyema runs an acute course followed by complete and permanent recovery, there are many cases that are protracted. The cavity fails to diminish in size or to become completely obliterated; improvement is interrupted by relapses, or a narrow and sometimes tortuous sinus is formed. These cases run an indolent course and are very refractory to treatment. Such cases are subject to transfer from one hospital to another, not infrequently with intercalated periods of active or limited duty, during which they are no longer under treatment and consequently escape continuous observation. These cases are, however, of great importance in a study of empyema with a view to deducing methods of treatment likely to avert the occurrence of chronic cases and to reduce the degree of ultimate disability.

In attempting to follow the histories of such cases it was necessary to devise some system which would keep the records of individual cases of empyema in current form in spite of transfers from one hospital to another and which could be continued for an indefinite period of time after discharge from military service. Such a system of records was started in January, 1919, while the hospital records still remained in the organizations where they originated. In the beginning, and in response to Circular Letter No. 23, Surgeon General's Office, dated January 10, 1919,[2] this system was based on the returns received on a special blank form.[3]

CIRCULAR LETTER NO. 23.

WAR DEPARTMENT,
OFFICE OF THE SURGEON GENERAL,
Washington, January 10, 1919.

Subject: Requests for abstracts of empyema cases.

1. It is desired to obtain accurate data concerning cases of empyema in the Army which can serve as a basis for a statistical study of this disease for immediate use and for the history of the war. To facilitate this collection of data, blanks are herewith sent, designed for use in preparing abstracts of the clinical course of these cases. These blanks should be invariably used. There will, however, be some cases for which they will prove inadequate. In such cases it will promote the work of compilation if the blanks are used as far as possible with supplementary sheets attached to them.

2. It is requested that the commanding officers of base and general hospitals assign a competent person to fill out these blanks as speedily as is compatible with accuracy. Completed blanks will be promptly sent to the Surgeon General, attention Laboratory Division.

3. In many hospitals the postoperative treatment of empyemata has not been continuously the same; yet many cases have, throughout a certain period, received substantially identical treatment. As the space allotted to postoperative treatment in the blanks will not permit of extended descriptions, it is requested that these descriptions be furnished separately, but that it be made clear on the blank during what period such method was employed in this particular case.

4. All cases in which empyema has been diagnosticated since May 1, 1917, should be included in these abstracts, whether completed or still in hospital.

5. To assist in securing the desired uniformity in the returns, the following explanatory memoranda are furnished to amplify the necessarily concise headings on the blanks:

1. *Serial numbers.*—If this is not on record, scratch "Serial" and give the register number.

2. *Diagnosis on admission.*—If this was pneumonia, so state with location and variety on line below. Note on back of sheet record descriptive of condition of patient; e. g., cyanotic, marked dyspnea, condition severely septic, delirious, etc.

3. *Empyema (pleurisy).*—Give date when fluid was detected in chest, irrespective of its character.

4. *Postoperative treatment.*—See paragraph 3, above.

5. *Secondary operations* refer only to those on the chest.

6. *Thoracic wound closed.*—Give recorded date when the wound or wounds made for the treatment of the empyema were completely healed.

7. *Disposition of patient.*—If in hospital, give number of ward.

8. *Laboratory reports.*—Include blood counts, white and red; determinations of hemoglobin; bacteriological examinations of blood, sputum, and fluids from the pleura or elsewhere.

9. *Memoranda of subsequent temperature.*—The desired information in many cases could be given as follows: "From (date) to (date) daily temperature rose above 100, with maximum to ——— and minimum of ——— for this period."

By direction of the Surgeon General:

C. R. DARNALL,
Colonel, Medical Corps, U. S. A., Executive Officer.

Copy to: Commanding officers all general, base and post hospitals, department surgeons.

EMPYEMA CASE ABSTRACT.

(For the Surgeon General of the Army, attention Laboratory Division.)

.... Hospital, at ...., ..., 1919.
Name of patient, ... Serial Number, ...
Home address, ... Admitted, ..., 191......
Diagnosis on admission, ... following ....
Pneumonia? Date .... Location, ... Variety, ...
Empyema (pleurisy). Date, ... Location, ...
Pneumothorax before operation? Date, ... Location, ...
Thorax aspirated? (Give dates, character of fluid, amount withdrawn.) ....
....
....
First operation: Date, ... Site, ...
Nature of operation: ....
Fluid evacuated: Character, ... Amount, ...
Postoperative treatment: ....
....
....
Secondary operations? Give dates and nature of operations. ....
....
....
Complications? (Give dates, nature of complication, treatment.) ....
....
....
Pleurobronchial communication? Date, ... Treatment, ...
Thoracic wound closed, ..., 191......
Disposition of patient, ..., 191.......
(In case of death, give autopsy findings on back of sheet, noting particularly any record of pulmonary abscesses.)
X-ray plates? Dates, ...
Laboratory reports: Blood, sputum, pleural and other exudates, with dates................
....
....

Daily maximum and minimum.	Temperature.	Pulse.	Respiration.
First 5 days in hospital from ...., 191...., to ...., 191......, incl....................................	....	....	....
	....	....	....
	....	....	....
Day before 1st operation..........................	....	....	....
Day of 1st operation..............................	....	....	....
Day after 1st operation...........................	....	....	....
1st normal temp ...., 191	....	....	....

Memoranda of subsequent rises of temperature above 100, with dates: ....
....
....

(Use back of sheet if above spaces are inadequate, and for special notes.)

D–420.

When the completed forms were received from any hospital, they were first arranged in chronological order according to the dates of admission to the hospital, consecutively numbered, and then filed according to these numbers. The names of the patients, their home addresses, the dates of admission, the hospitals, and chronological numbers were entered on cards arranged alphabetically by surnames. All later information concerning transfers, operations, etc., was added to these files.

The empyema case abstracts served not only as a beginning of the record in following the progress of the case, but furnished the first data of a continuous clinical history designed to extend beyond the period of military service.

Follow-up letters.—At intervals of a few months letters of inquiry were sent to the patients at their home addresses, and the replies entered on the records. One of these letters is reproduced here.

In reply refer to S. G. O.............. Mills 100.

WAR DEPARTMENT,
OFFICE OF THE SURGEON GENERAL,
Washington, Aug. 26, 1920.

MY DEAR MR. ....,[4]
San Francisco, Calif.:

I am directed by the Surgeon General to inquire about your present health, and whether you have had any recurrence of your empyema or any other trouble of any nature.

Please answer the questions below in the space provided, and send this letter to this office in the inclosed envelope, which requires no postage.

Very sincerely yours,

....

1. Full name. .... Home address, ...
   In what military hospital were you treated? ....
   Were you overseas? ....
2. Does your empyema bother you? .... In what way? ....
   Normal weight? .... Weight when discharged? .... Weight now? ....
3. Have you any other trouble? ....
   If so, describe in detail ....
4. Date of discharge from the Army ....
5. What work have you done since your discharge? ....
6. If a doctor is looking after you, give his name and address.................................
7. Claim number? ....

These methods helped to maintain contact with patients while they remained in the service, and, still more important, after their discharge, when a change of residence might take place. Otherwise the records of some cases would have been terminated prematurely.

It is obvious that reports rendered by the patients themselves could be of only relative value and chiefly subjective in character. Notwithstanding these limitations, they proved of great importance in following the progress of many cases.

Physical examinations.—When it appeared probable that a case had reached a condition in which further change was not to be expected, or when a case was running a very protracted course and remained under medical care or super-

vision, a follow-up letter, coupled with a request for a physical examination, was substituted for the usual inquiry. In the absence of funds available for this purpose it was possible to obtain the desired cooperation only through the courtesy of the physician making the examination, and in nearly every instance this courtesy was cordially extended by the physician to whom the request was sent.

The Bureau of War Risk Insurance of the Treasury Department heartily supported this undertaking as far as was possible, but it was not authorized to order special examinations solely to promote a study of empyema.

The cooperation extended by this bureau was of inestimable value, for many of the physicians caring for these soldiers after their discharge from the Army were medical men selected by this bureau to make the examinations required in fixing the compensation to which the men were entitled.

Copies of the forms used are reproduced here:

In reply refer to S. G. O. ....

WAR DEPARTMENT,
OFFICE OF THE SURGEON GENERAL,
WASHINGTON.[5]

MY DEAR ....

I am directed by the Surgeon General to inquire about your present health and whether you have had any recurrence of your empyema or any other trouble of any nature.

Information concerning the physical condition after their return to civil life of men who have had empyema while in the service is of importance for a better knowledge of this disease and its treatment.

Please answer the questions below in the space provided and send this letter back to this office in the inclosed envelope, which requires no postage.

Very sincerely yours,

....

1. Full name .... Home address ....
   In what military hospital were you first treated for empyema?..........................
2. Does your empyema now bother you? .... In what way?.......................
3. Have you any other trouble?...
   If so, describe in detail...
4. Are you receiving compensation?...
   What is your claim number?...
5. Do you report to a doctor from time to time?...................................
   If so, give his name and address...
6. The next time you go for examination, give the inclosed letter, blank and envelope to the doctor.

WAR DEPARTMENT.
OFFICE OF THE SURGEON GENERAL,
WASHINGTON.[6]

MY DEAR DOCTOR: In cooperation with the Bureau of War Risk Insurance, the Surgeon General of the Army has requested me to inquire into the present physical condition of men who have had empyema while in military service and now returned to civil life. This information, when connected with the previous histories of these cases, will throw important light on the pathology and treatment of empyema and will be utilized in preparing this section of the Medical History of the War.

I venture to ask the courtesy of your aid in furthering this undertaking by employing the accompanying form when next determining the physical condition of the bearer of this letter.

If there are features of special interest in this case not covered by this form, I beg that you will note them on the back.

When filled out, please mail the form to the Surgeon General of the Army, for which purpose a return envelope is furnished.

There are approximately 5,000 cases of empyema among the troops on this side of the Atlantic and I am confident that you will appreciate the value to our profession of a study of the sequelæ of this disease a year or more after discharge from the hospital where first treated.

Very sincerely yours,

....

CASE OF EMPYEMA OF THE THORAX.

Record of examination made by... On..................192....
Full Name ....Home Address ....
Claim Number.......... Age........ Former occupation............ Present occupation..............
First treated for empyema at..; ....19.....
First operation.................... 19.... Thoracotomy? .... Rib-resection? .... Site? ....
(Note subsequent operations on back of sheet)
Weight before illness? .... Present weight? .... Excessive cough? ...... Excessive sputum? ......
Bloody sputum? ...... Foul sputum? ...... Dyspnoea on exertion? .... Deafness? ....
Pain on normal respiration? .... On forced respiration? .... Location: ....
Precordial pain? .... Pain on moving arms? .... Limits of motion: ....
Faintness or dizziness on exertion? .... Tremor of fingers? ....
Condition of joints? ....
Cyanosis? .... Swelling of legs? .... Of feet? .... Clubbed fingers? ....
Temperature .... degrees at .... M. (afternoon temperature preferred)

	Pulse,	Respiration,	Blood pressure
Observations on			
After quiet, in recumbent position,	....	....	....
Recumbent, just after 30 seconds stationary run,	....	....	....
Recumbent, ... minutes (2 to 5) later,	....	....	....

Is thyroid enlarged? .... Tâche on chest after friction with finger? ....
Liver, level of lower margin? .... Ascites? ....

HEART: Location of apex beat? .... Valvular lesions? ....
Location left border of cardiac dullness .... cm. from mid-line, 5th intercostal space.
Locate murmurs or thrills on Diagram, stating whether systolic or diastolic.

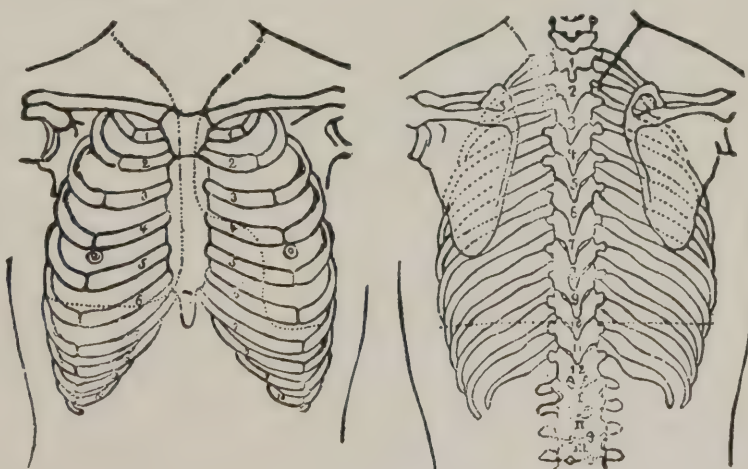
CHEST: Deformity? ....
Curvature of spine? ....
Sinus still open? .... Does it enter a cavity? .... Size of cavity? ....
Amount and character of discharge? .... Character of scars? ....
Is there evidence of pus in the chest? .... Lung abscess? .... Tuberculosis? ....
Note physical signs on following Diagrams:

RALES:
f—fine
m—medium
c—coarse
s—sonorous
ck—crackling

BREATH SOUNDS:
BF—feeble
BE—Bronchial expiration
BI—Bronchial inspiration

PERCUSSION:
DULL—LIGHT SHADING
FLAT—HEAVY SHADING
T—Tympany
MARGINAL NOTES FOR OTHER SIGNS, WITH INDICATORS

Locate position and size of scars.



URINE: Specific gravity .... Albumin .... Sediment ....

(If more space is required for any data use back of sheet)

FIG. 1.—Blank for physical examination.

Beginning with Circular Letter No. 23, the data obtained in the ways just described will be hereafter collectively referred to as the "Special empyema records."

Reports of certain special details from empyema centers.—When the military hospitals were abandoned, the cases of empyema were evacuated to other hospitals. There were seven hospitals which became recognized as centers specially equipped for the care of these cases.[7] They were General Hospital No. 12, at Biltmore, N. C.; Fort McPherson, Ga.; Fort Sam Houston, Tex.; The Letterman General Hospital, San Francisco; Fort Des Moines, Iowa; Fort Sheridan, Ill.; and the Walter Reed General Hospital, Washington, D. C. From three of these centers special monthly reports [8] on the cases under treatment were sent to the Surgeon General, and on completion of the cases a general summary of the history and final condition of each patient was also forwarded. The following blanks upon which this information was transmitted were used:

(To be sent monthly to the Surgeon General, U. S. Army, Washington, D. C. Attention Laboratory Division.)

Case of empyema. Current record. U. S. A. General Hospital No. .... From .... to ...., 1919.

Name .... Serial or Register No. ....

Permanent home address in full ....

Admitted ...., 191.... Overseas case? ...... Transferred from ....

I. Bacteriological data: Numbers of colonies on plate cultures; hemolytic streptococci (H), pneumococci (Pn), total colonies (T):

....

....

II. Antiseptic treatment: *a*, Antiseptic used; *b*, strength; *c*, amount; *d*, frequency of application, with dates of beginning, interruptions, changes, and cessation:

....

....

III. Measurements of cavity, with dates:

....

....

IV. Temperature. Note only temperatures of 100 or over, with dates between which such rises occurred and the maxima:

....

....

V. Weights of patient: *a*, Normal weight on entering service; *b*, record of weights while in hospital, with dates:

....

....

(For additional notes, or if spaces are inadequate, use back of sheet.)

(On completion, to be sent to the Surgeon General, U. S. Army, Washington, D. C. Attention Laboratory Division.)

Case of empyema. Clinical outline. U. S. General Hospital No. .... 1919.

Name .... Date of admission ....

Empyema followed: 1, Measles; 2, influenza; 3, pneumonia not preceded by measles or influenza; 4, trauma; 5, other primary disease or idiopathic:

....

....

Nature of all operations, with dates and hospitals:

....

....

X-ray plates with (without) injection of cavity, with dates and serial numbers of plates:

....

....

Description of case on admission and while in hospital with outline of treatment:

....

....

Disposition of case, with description of condition on discharge from hospital, or summary of autopsy findings:

....

....

(For additional notes, or if spaces are inadequate, use back of sheet.)

Clinical records transmitted to the Surgeon General.—After the closing of military hospitals, their clinical records were forwarded to the Surgeon General at Washington,[9] and they then became accessible as a source of information supplementing that obtained through the channels already described. Protocols of autopsies and, in some instances, pathological material secured at necropsy, were sent to the Army Medical Museum. This material also was available for study.

Publications by Government departments and in current medical journals.—In many of the military hospitals within the United States, the number of cases of empyema was so large and they presented conditions so unlike those most commonly observed in civil practice that the attention of surgeons of the Medical Reserve Corps was forcibly directed toward developing improved methods of treatment. This led to an intensive study of the disease and to the publication of numerous articles in current medical journals dealing with various aspects of the subject. Groups of medical officers were assigned to duty on empyema teams which comprised a surgeon, an internist, and a member of the laboratory staff.[10] A special empyema commission was placed in the base hospital at Camp Lee [11] where about 140 cases were available for study. The observations and conclusions accruing from these efforts were summarized at intervals so that they were available for study.[12] More specific references to these sources of information will be found in other parts of this study.

Circular Letter No. 93.—Cases which were transferred from hospital to hospital were followed by means of monthly lists [13] sent to the Surgeon General from all the military hospitals throughout the country in response to Circular Letter No. 93.[14] These lists contained the names of all patients under treatment at the time, with the dates of the operations. Unfortunately, the addresses of the patients were not included and the hospitals at which the operations were performed were not designated. These omissions often rendered the identification of the cases difficult and at times uncertain, particularly when there were discrepancies in spelling. These lists, however, served as invaluable checks on the accuracy of the data gathered through other means and frequently directed attention to operations that might otherwise have escaped record. They also supplied the first data concerning a number of chronic empyemata received in this country from overseas.

THE UTILIZATION OF SPECIAL DATA CONCERNING CASES OF EMPYEMA.

The empyema case abstracts gave the initial, detailed information regarding the clinical histories of individual cases. It was necessary to reduce them to some form so that they might be compared with respect to the character of the cases in different parts of the country, and so that groups of cases in particular localities might be studied epidemiologically.

Tally sheets[15] were prepared for this epidemiologic study. One of these is reproduced here to illustrate the data they contained. The numerals placed under the various headings are the chronological numbers assigned the individual cases. These sheets made it possible to detect coincident conditions in a given case by following its number through the various captions under which it might be placed. A study of these sheets shows the prevalence of measles, influenza, pericarditis, etc., among the patients in the base hospitals of the camps.

Tally sheet, empyema case abstracts, General Hospital No. 6, Fort McPherson, to March 3, 1919.

A. Abscess, abdominal wall.
 do. buttocks.
 do. extremities, 194.
 do. liver, 201.
 do. mediastinum.
 do. pulmonary, 24, 46, 47.
 do. rectal, 76.
 do. thoracic wall.
 Adenitis, 46, 47.
 Appendicitis, 4, 191, 208.
 Arthritis, 37, 57, 58, 54.
B. Blood cultures, neg. 22, 23, 33, 36.
 do. posit. 42, 139, 163.
 Counts, good.
 Balsam of Peru.
 Bismuth paste, 14, 108, 109, 111.
C. Chloramine–T.
 Castor-oil balsam, 133.
 Chloroform.
 Cocaine.
 Cystitis.
D. Dakin's sol. 13, 18, 19, 20, 22.
 Dichloramine–T, 22, 25, 33, 42.
 Decortication 1, 2a, 3, 48, 51.
 Diphtheria 121, 148, 159, 165.
 Delirium.
E. Electric cautery.
 Emphysema.
 Empyema, double 35.
 Embolism.
 Endocarditis 42, 43, 87, 101.
 Epilepsy.
 Erysipelas 152.
 Ether.
 Expectoration of pus, 203.
F. Foreign body, pleural cavity.
 Formaldehyde.
 Formalin, intravenous.
G. Gangrene, pulmonary.
 German measles 7.
 Glucose, intravenous.
G. Gunshot wound, 232, 240, 251, 260.
H. Hemorrhage, intestinal mucosa.
 Herpes.
 Hemorrhage, punctate 249a.
 Hemorrhage, lungs.
I. Influenza 126, 206, 209, 212, 229.
 do. bacillus, 25, 34.
 Infarction.
 Infection.
 Infection, mixed, 35, 57, 92, 93.
 Intravenous medication.
J. Jaundice.
K.
L. Laryngitis.
 Liver.
M. Measles 3, 9, 11, 13, 15, 16.
 Meningitis.
 Mumps 25, 26, 37, 112, 124.
 Mastoiditis 21.
N. Nephritis, 53, 148, 241.
O. Orchitis, 28, 169.
 Otitis media, 36, 150, 151.
 Osteomyelitis, 111.
P. Pericarditis, 36, 43, 68.
 Phlebitis, 150.
 Pneumococcus, abscess.
 Pneumothorax, 78.
 Pharyngitis.
 Pleuritis, fibrinous, opp. side 113, 42, 487.
 Pleurobron. commun. 190, 206.
Q.
R. Recurrences.
S. Saline irrigation, 250.
 Serum, tr., 16, 126.
 Scarlet fever.
 Suction, 23, 266.
 Strept. nonhem.
 Sec. opera. 1, 9, 13, 14, 18, 19, 21.
 Staphylococcus, 37, 54, 66, 92, 96.
 Silver nitrate 6.
 Sinusitis.

T. Tuberculosis 5, 34, 46, 47.
Transfusion.
U. Ulcer.
V. Vaccine 22, 126.
Vomiting.
W.
X.
Y.
Z.

Follow-up replies:
Well.
Handicapped.
Reoperated.

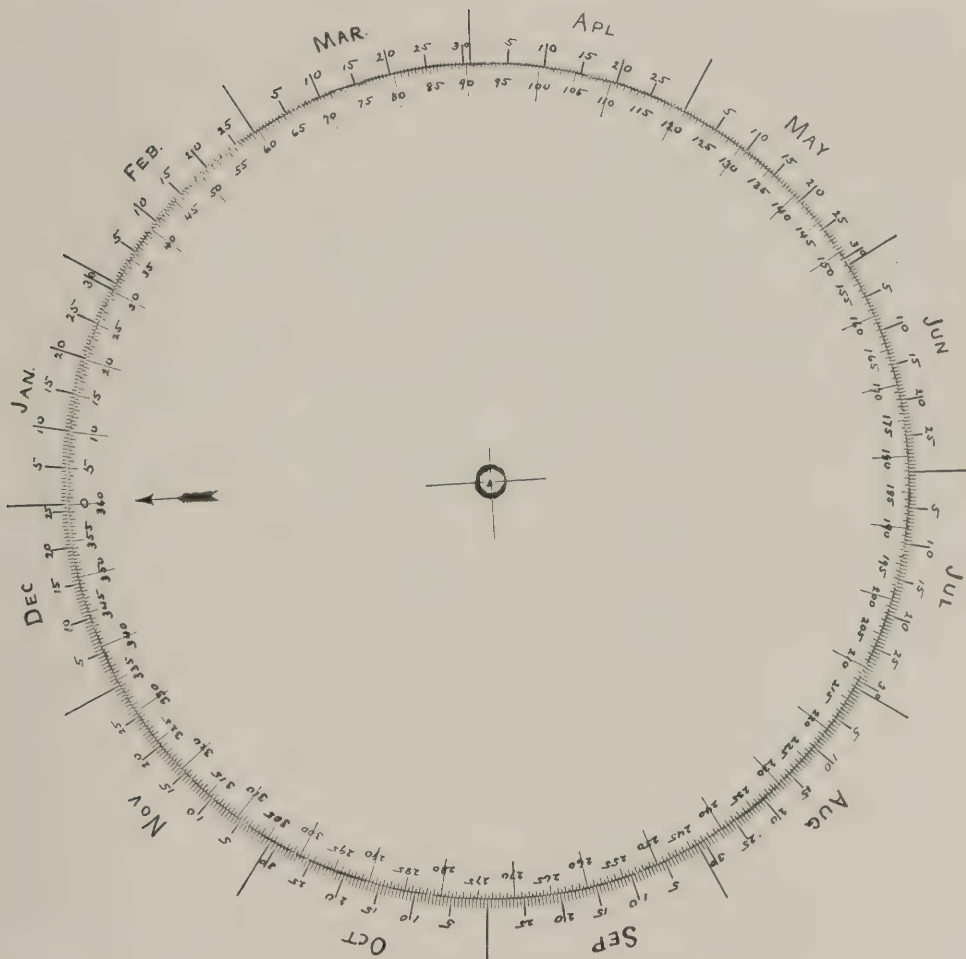


FIG. 2.—Device for determining intervals in histories.

The first step in reducing the data furnished by the empyema case abstracts to a form permitting ready comparison of individual cases was "intervalling" the events in the clinical histories. Starting with the day of admission to the hospital as zero, the number of days that had elapsed when a given event occurred was determined and the corresponding number written over the event on the original record. A mechanical device was invented to facilitate the reckoning of these intervals. This device [a] is shown in Figure 2. The

[a] It was subsequently learned that a similar device, divided to include 365 days for five years and called a "Hemerametre," was employed in the French Army.

degrees of a cardboard protractor were numbered consecutively from 1 to 360 to represent the calendar from January 1 to December 26 (one year, less five days). The centers of the two protractors were pivoted over each other so that the smaller scale revolved upon the larger. By placing the zero of the numbered scale in coincidence with any given date on the calendar scale it was possible to read off at a glance the number of days between that date and any other given date, provided the two were less than a year apart. If the division representing December 26 was passed in using this device, five days were added, or the zero mark of the numbered scale was set back five days. This was because the circles were divided into 360 degrees, while the year has 365 days. For a like reason, a day was added if February 28 was crossed in making readings for leap year.

When the events recorded on the case abstracts had been intervalled, they were entered in abbreviated form on the briefs described. These briefs were the working sheets used in studying and comparing the individual cases.

Preparation of case briefs.[16]—The term "case brief" was applied to abbreviated records of the clinical histories of cases of empyema, arranged according to a plan which permitted ready comparisons. A relatively simple history in the briefed form is reproduced in Chart I. The left of the caption gives the name of the patient, his home or permanent address, the date of his admission to the hospital where he was first treated for empyema, and the diagnosis at the time of admission. At the right of the caption is the hospital with a superimposed memorandum of the maximum recorded capacity of the empyema cavity. This memorandum was taken from the reports of the amounts of fluid withdrawn at any one time either by aspiration or at operation. Following the hospital designation is the chronological number of the patient, and beneath it are his register or serial number, a letter indicating the disposition made of the patient, followed by the number of days that had then elapsed after his admission, and an abbreviation for the microorganisms found in the pleural exudate. On the following line is the date of disposition. Beneath the caption, penciled rulings make it possible to pick out any desired square in this area of the cross-sectioned paper on which the brief was written. Each square represents a single day in the clinical history of the patient. The square in the left upper corner was used for the first day after that on which he was admitted to the hospital. The sizes of the page and squares permit a daily record extending somewhat over two years. The margin to the right of the ruled area contains details which could not be inserted in the squares, or memoranda of special interest which might be overlooked unless given this emphasis.

The history chosen as an example may be written out in the following terms:

The patient was admitted to the base hospital, Camp Dodge, Iowa, on March 27, 1918. The diagnosis on admission was influenza with lobar pneumonia in the right lower lobe. Two days later, he developed diphtheria and received 20,000 units of antitoxin. On the eighth day after admission an effusion was detected in the right pleural cavity and 1,200 c. c. of turbid yellow fluid containing hemolytic streptococci were withdrawn by aspiration. The following day 450 c. c. were removed.

On the 21st day, April 17, resection of the eighth rib in the right post-axillary line was done and 1,000 c. c. of creamy yellow pus were evacuated. Simple drainage, with daily dressings, constituted the postoperative treatment for the following six weeks. At this time he had been in the hospital 63 days. Carrel-Dakin antisepsis was then instituted and continued for 11 days, after

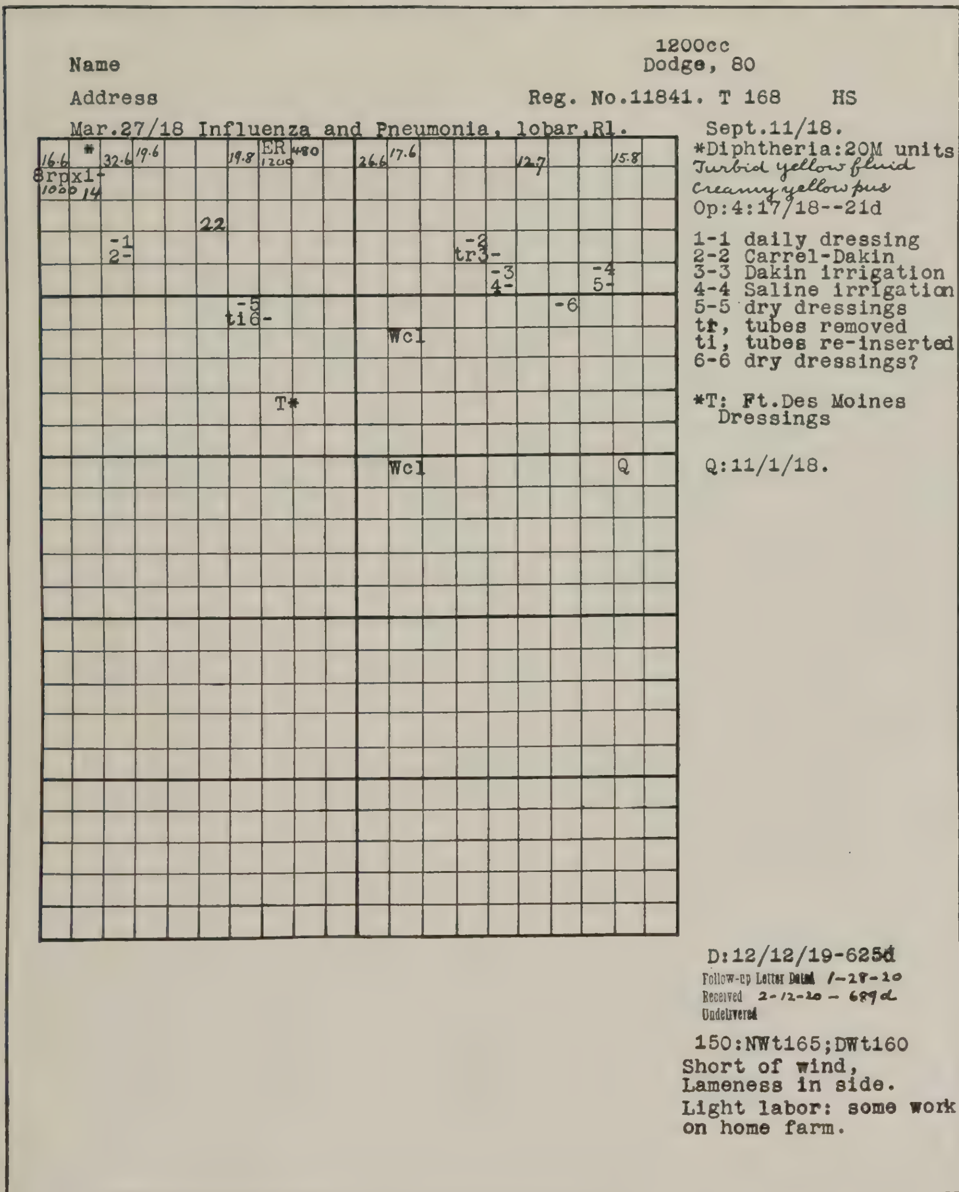


CHART I.—Final condensed brief of case.

which the tubes were removed and the application of Dakin solution limited to a single daily irrigation. It is obvious that at the end of this period progress was not wholly satisfactory because a tube was reinserted on the one hundred and seventh day to secure greater freedom of drainage, but there is no evidence that other treatment beyond simple dressings was employed. Ten days later

the tube was again removed and the cavity was allowed to close 132 days after the patient was admitted to the hospital. The closure was not permanent.

On September 11, the one hundred and sixty-eighth day, the patient was transferred to Fort Des Moines, where dressings of the thoracic wound were continued until final closure on the two hundred and twelfth day, and one week later he was sent to quarters. He was discharged from the Army on December 12, 1919, which was 625 days after his admission to the hospital at Camp Dodge and 406 days after his return to duty.

In response to a letter of inquiry, this patient reported on February 12, 1920, two months after he had received his discharge from the Army, that his weight was 150 pounds, his normal weight was 165 pounds, and his weight at the time of discharge 160 pounds, that he was "short of wind, experienced lameness in his side, and was doing light work on the home farm."

When, as in this case, there are records of leucocyte counts, they were entered with a pen in red ink in the squares corresponding to the days of observation, the figures being thousands and fractions of thousands.

In the event of death, notes of the autopsy findings, when available, were transcribed upon the briefs.

Since the salient features of each case were noted on the right margin of the page, the briefs could be easily grouped according to similarities or divergencies in the course of the disease or the character of treatment. This flexibility of the system facilitated greatly the comparative study of the large number of cases for which histories were available. Furthermore, the preparation of these briefs called attention to gaps in the histories which it was often possible to fill by searching for the missing information. Cases with exceptional features were rendered prominent by this method of recording.

It is obvious that these briefs were not only useful in the way just mentioned, but that they also served as an index to the more voluminous records from which they were prepared.

The number of briefs, follow-up letters, and autopsy records for cases of empyema admitted during 1917 and 1918 for which data were collected in the manner described is shown in Table I.

TABLE 1.—*Summary of cases included in the special empyema records for 1917 and 1918.*

Camps.	Survived.		Died.		Camps.	Survived.		Died.	
	Briefs.	Follow-up letters.	Briefs.	Autopsies.		Briefs.	Follow-up letters.	Briefs.	Autopsies.
Beauregard	68	53	28	0	MacArthur	19	12	2	0
Bowie	144	79	77	48	McClellan	41	29	2	2
Cody	107	51	32	9	Meade	60	50	28	9
Custer	155	92	63	32	Merritt	64	48	68	26
Devens	77	54	21	21	Mills	86	47	33	0
Dix	71	55	19	3	Pike	188	159	90	57
Dodge	126	77	216	177	Sevier	34	26	18	16
Eustis	8	0	1	1	Shelby	40	24	8	6
Fremont	17	9	0	0	Sherman	87	67	89	54
Grant	121	74	29	19	Stuart	33	22	6	0
Greene	67	52	36	24	Travis	134	107	29	8
Gordon	119	58	32	12	Upton	54	12	24	2
Hancock	40	26	9	2	Wadsworth	28	19	17	11
Humphreys	17	0	8	0	Wheeler	80	38	49	19
Jackson	14	0	2	0		2,356	1,496	1,096	600
Johnston	23	18	6	0	General and debarkation hospitals	426	291	91	20
Kearny	6	5	18	18	Forts and miscellaneous	157	78	73	16
Lee	146	101	24	18		2,939	1,865	1,260	636
Lewis	70	25	7	6					
Logan	31	19	7	0					

REFERENCES.

(1) Questionnaire of February 21, 1918, S. G. O. (Sent to all base hospitals.) On file, Record Room, S. G. O., 710 (Empyema).

(2) Circular Letter No. 23 (D-386) January 10, 1919. On file, Historical Division, S. G. O., Empyema.

(3) Empyema case abstracts Form D-420. On file, Record Room, S. G. O., 710 (Empyema).

(4) Letter from the Surgeon General, U. S. Army, to Charles A. Ramsher, August 26, 1920. Subject: Inquiry regarding health. On file, Record Room, S. G. O., 710 (Empyema, Mills 100).

(5) Letter from the Surgeon General, U. S. Army, to discharged empyema patients (various dates). Subject: Present health. On file, Record Room, S. G. O., 710 (Empyema).

(6) Letter from the Surgeon General, U. S. Army, to Examining physician (various dates). Subject: Report on empyema cases. On file, Record Room, S. G. O., 710 (Empyema).

(7) Annual Report of the Surgeon General, U. S. Army, 1919, Vol. 11, 1092.

(8) Monthly reports, empyema cases. On file, Record Room, S. G. O., 710 (Empyema).

(9) Clinical records. On file, Medical Records Section, A. G. O., Retained Hospital Files under name individual hospital.

(10) Letter from the Sugeon General, U. S. Army, to Commanding Officers of all Hospitals, April 13, 1918. Subject: Empyema. On file, Record Room, S. G. O., 710 (Empyema).

(11) Report from Major Allen B. Kanavel, M. C., to the Surgeon General, U. S. Army, April 25, 1918. Subject: Empyema Commission. On file, Record Room, S. G. O., 710 (Empyema).

(12) Empyema Commission reports from Camp Lee. On file, Record Room, S. G. O., 710 (Empyema, Camp Lee) (c).

(13) Monthly lists, response to Cir. Letter No. 93. On file, Record Room, S. G. O., 710 (Empyema).

(14) Circular Letter No. 93, W. D., S. G. O., to All Military Hospitals, February 14, 1919. Subject: Empyema. On file, Record Room, S. G. O., Document file.

(15) Tally sheets. On file, Record Room, S. G. O., 710 (Empyema).

(16) Briefs of empyema reports. On file, Division of Surgery, S. G. O., Empyema.

CHAPTER II.

EPIDEMIOLOGY.

STUDY OF THE COMBINED DATA FROM TWENTY-THREE CAMPS.

The records obtained in the manner described in the preceding chapter show that cases of empyema occurred in camps in all parts of the United States. The incidence of these cases falls into two main groups. The first comprises those occurring in the fall of 1917, soon after the camps were established, and during the early months of 1918. The second period of high incidence began in the late summer and fall of 1918 and extended in some instances into the early months of 1919. Between these two groups of high incidence, the cases in a given camp were either very small in number or a period of one to three months elapsed in which no new cases were reported.

The reports received from 23 base hospitals are sufficiently full to give a clear picture of the incidence of empyema in the respective camps. These data are depicted by diagrams in Figure 3. An enlargement of the diagram for the first camp, Camp Devens, appears in the lower left corner, and will serve to explain the plan used in preparing those of all the camps. Two fine vertical lines separate the months of 1918 from those of the preceding and following years; and the black columns indicate the incidence of empyema as the ratio per thousand men in the camps for the respective months.

Since these ratios differed very widely, they could not be represented conveniently in their simple arithmetical relations. For example, at Camp Devens, there were two cases of empyema reported for August, 1918.[1] As the strength for that month was 40,048,[2] the empyema ratio per thousand was therefore 0.050. The next month, with the advent of influenza, the number of reported cases of empyema rose to 52,[1] giving a ratio of 1.148 per thousand men, the strength of the camp for that month being 45,308.[2] In October the ratio fell to 0.049, almost identical with that of August. It will be observed from these figures that the ratio for September rose to approximately 23 times that for the adjacent months. To have given the column for September this relative height on a simple arithmetical scale would have carried it beyond the confines of the map. For the presentation of such widely divergent figures in a compact form, it was necessary to employ a scale which would compress the large quantities into small compass and yet preserve the relation accurately. A logarithmic scale, fulfilling these conditions admirably, was employed in preparing the diagrams upon the map. To simplify the reading of the diagrams, horizontal lines were drawn to give the heights of the columns. These horizontal lines correspond to the ratios 0.1 and 1 per thousand men, respectively. On the enlarged diagram the ratios of 0.05 and 0. 5 are also given to show the diminishing increment by which the columns lengthen as the numbers they represent increase.

The use of the logarithmic scale proved so valuable in the studies for this chapter that a diagram is introduced here in explanation of its advantages.

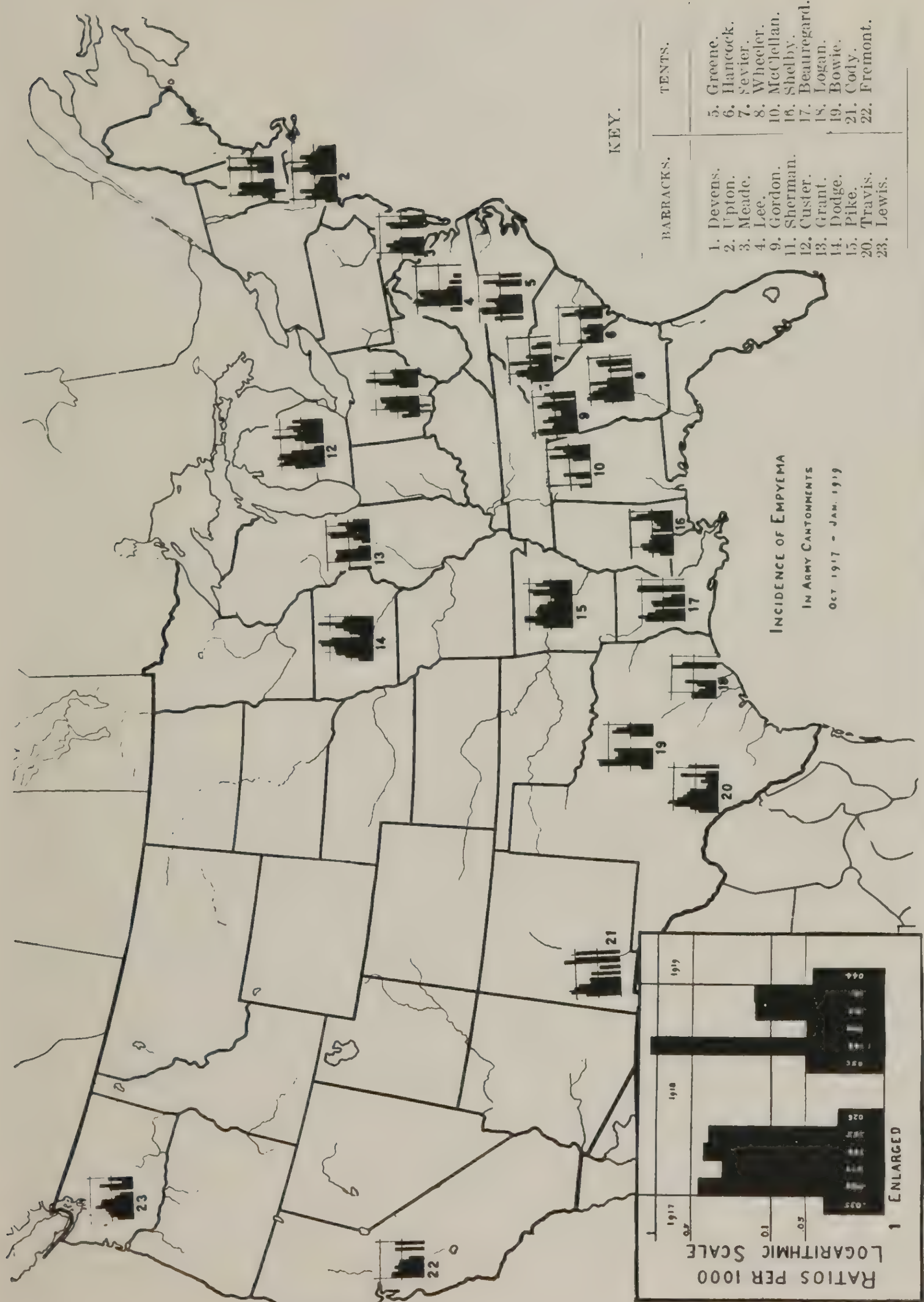


FIG. 3.—Incidence of empyema in Army camps and cantonments from October, 1917, to January, 1919, inclusive.

In Figure 4 a series of columns, representing successive numbers from 2 to 30, are shown in close contact with each other. Four of these columns are marked with the numbers they represent, 2, 4, 8, and 16. Column 4 is twice the height of column 2 and half the height of column 16. Doubling the height of a column squares the number it represents. If the column 2 were superposed on 4, the combined height would equal 8, but if the 2 were added to 8, the sum of the two would reach the level of 16. Adding any column furnishes a total height which, on this scale, is equivalent to the product of the numbers they indi-

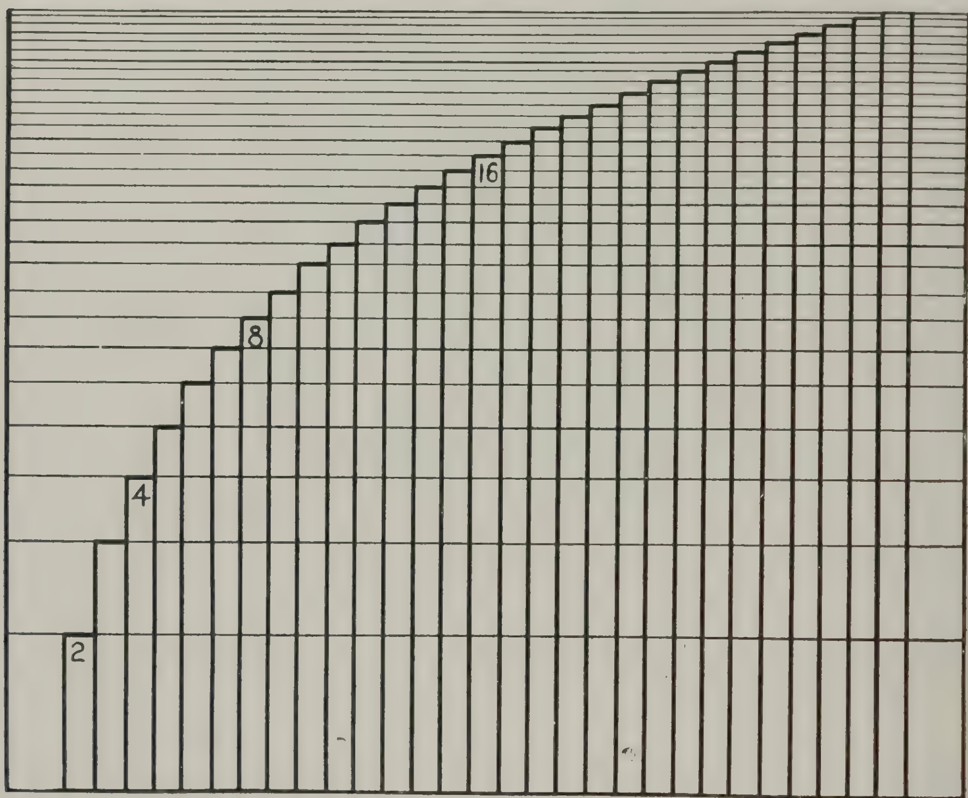


FIG. 4.—Diagram of logarithmic scale.

vidually represent. It follows that, if two lines charted upon this scale are parallel, the quantities they represent are in the same ratio to each other at any two points on the same vertical line, since the constant distance between them represents the quotient resulting from dividing one by the other. If they converge, this ratio approaches unity. If they diverge, the ratio correspondingly departs from unity. The value of the properties of the logarithmic scale will become evident when the incidence of empyema in relation to other diseases is studied in the individual camps, since it reveals at a glance the constancy of variations in the ratios for the figures plotted.

Referring again to Figure 3, it will be noted that, in general, those camps in which the men were lodged in tents fared better than those providing frame barracks for the men. This is especially true in the earlier groups of cases which occurred in the later months of 1917 and early in 1918. Camp Logan, No. 18 (tents), compares favorably with Camp Travis, No. 20 (barracks), Camp McClellan, No. 10 (tents), with Camp Gordon, No. 9 (barracks). On the other hand, Camp Bowie, No. 19 (tents), shows a higher incidence during November and December, 1917, than Camp Travis, though the termination of this outbreak was as abrupt as and coincident with that at Camp Logan. Again, Camp Sevier, No. 7, and Camp Wheeler, No. 8 (both tents), show no very marked contrast to Camp Gordon, No. 9 (barracks).

The mode of housing the men was only one of the differences between the tent camps and those with barracks, as the men brought to each class of camp were drawn from somewhat different sources. Those in barracks were drafted men, constituting the National Army,[3] while the National Guard, which consisted in part of men having at least some previous conception of military life, was brought together in the camps provided with tents.[4] That previous military life, so far as this went, did not very materially protect men from empyema is shown by the figures, and their experience in caring for themselves under Army conditions, played no important part in the incidence of empyema. While camps in which the incidence was smallest are among those in which tents were used and the men more experienced, the contrast between these camps and the others is not sufficient to be stressed. The average incidence per month for December, 1917, January, February, and March, 1918, in tent camps was 0.397; in those with barracks, 0.555 per thousand men in the commands; or, expressed in percentages, monthly ratio in tents, 41.7 per cent; in barracks, 58.3 per cent.

During the period of high incidence in the autumn of 1918, these differences appear less striking. The figures for September, October, and November, 1918, confirm this impression, the average monthly ratio of incidence being 0.447 for the 11 tent camps and 0.482 for the 12 others—47 per cent and 53 per cent, respectively. No appreciable difference existed in the camp populations at this time.

In the current literature there is frequent reference to an association of empyema with measles during the early period, and with influenza in the later epidemic. The relations between the incidence of these diseases and other respiratory infections to that of empyema will be illustrated presently by charts for individual camps, but first it will be well to learn what light can be thrown upon the relation of empyema to measles by a collective study of the available statistics bearing upon this particular question. In the Office of the Surgeon General, United States Army, the admissions for measles to the military hospitals have been tabulated for each month from September, 1917, to December, 1919.[5] From these data and from special empyema records[6] Table 2 has been prepared to show the comparative incidence of measles and of empyema.

TABLE 2.a—*Incidence of measles, empyema, and pneumonia and empyema following measles.*

Camps.	1917											
	October.				November.				December.			
	Measles.	Measles—pneumonia.	Empyema.	Measles—empyema.	Measles.	Measles—pneumonia.	Empyema.	Measles—empyema.	Measles.	Measles—pneumonia.	Empyema.	Measles—empyema.
Devens	2	0	0	0	33	0	0	0	165	1	1	1
Upton	1	0	0	0	6	1	0	0	37	6	1	0
Meade	6	1	0	0	49	0	0	0	112	1	1	1
Lee	1	0	1	0	211	4	0	0	222	14	34	9
Greene	56	1	3	0	125	1	0	0	444	6	20	10
Hancock	0	0	0	0	2	0	0	0	8	0	0	0
Sevier	307	24	2	1	2,295	229	4	1	126	24	12	3
Wheeler	500	22	5	1	2,335	86	35	11	90	8	44	2
Gordon	61	0	0	0	197	2	0	0	498	27	22	14
McClellan	39	0	0	0	57	2	0	0	118	2	1	0
Sherman	10	0	2	0	46	0	1	0	149	0	8	0
Custer	25	0	0	0	112	0	0	0	180	1	5	3
Grant	4	0	3	0	13	0	0	0	139	2	0	0
Dodge	22	1	1	0	82	2	4	0	255	4	9	3
Pike	974	36	5	2	1,862	81	14	5	1,295	93	47	24
Shelby	118	3	1	0	1,173	36	4	3	277	15	7	2
Beauregard	149	6	0	0	1,566	130	11	5	130	20	27	4
Logan	12	0	0	0	23	1	4	0	195	2	4	1
Bowie	282	11	1	0	2,925	238	76	42	143	35	71	13
Travis	31	3	0	0	2,608	63	6	5	1,382	53	30	10
Cody	14	1	0	0	153	11	7	0	155	14	39	6
Fremont	0	0	0	0	0	0	0	0	0	0	0	0
Lewis	12	0	0	0	41	0	2	0	82	1	4	0
Total	2,626	109	24	4	15,914	887	168	72	6,202	329	387	105

Camps.	1918																			
	January.				February.				March.				April.				May.			
	Measles.	Measles—pneumonia.	Empyema.	Measles—empyema.	Measles.	Measles—pneumonia.	Empyema.	Measles—empyema.	Measles.	Measles—pneumonia.	Empyema.	Measles—empyema.	Measles.	Measles—pneumonia.	Empyema.	Measles—empyema.	Measles.	Measles—pneumonia.	Empyema.	Measles—empyema.
Devens	237	8	12	3	48	1	7	3	43	1	11	0	24	0	11	0	81	5	1	0
Upton	17	2	7	0	7	0	4	0	32	2	16	0	57	4	4	0	15	2	1	0
Meade	70	5	11	1	59	4	10	1	31	0	16	2	27	2	6	0	25	1	4	0
Lee	172	13	43	11	72	6	16	1	16	0	23	0	22	0	27	1	58	2	2	0
Greene	563	10	33	18	103	2	6	1	120	4	7	0	45	1	10	1	10	0	2	0
Hancock	34	2	4	0	78	1	2	0	44	0	1	0	12	1	2	0	2	0	1	0
Sevier	28	2	12	0	24	0	4	0	6	1	1	0	48	5	10	0	32	1	1	0
Wheeler	15	0	16	1	4	0	10	0	2	0	3	0	6	0	18	0	7	0	3	0
Gordon	248	18	21	13	12	0	4	1	47	0	4	0	106	11	12	0	194	11	6	0
McClellan	164	4	0	0	73	0	0	0	36	0	1	0	7	0	4	0	6	0	0	0
Sherman	593	5	12	5	258	3	10	5	59	2	13	1	33	2	18	0	50	0	0	0
Custer	201	1	27	8	59	0	15	13	15	1	25	0	28	2	26	1	24	0	9	3
Grant	384	7	12	4	82	0	8	2	46	0	9	0	65	0	10	1	60	0	1	0
Dodge	262	0	12	2	119	1	13	0	407	2	64	4	154	12	69	9	65	3	23	3
Pike	233	29	43	13	44	1	12	2	77	4	14	2	96	2	11	0	94	5	12	0
Shelby	14	0	8	0	3	0	3	0	4	0	2	0	8	0	3	0	8	0	0	0
Beauregard	7	2	13	0	4	0	5	0	3	1	0	0	4	0	6	0	3	0	7	0
Logan	153	10	2	0	130	8	1	1	25	0	2	0	39	1	8	0	10	0	0	0
Bowie	8	0	13	0	5	0	10	0	2	0	10	0	0	0	14	0	2	0	0	0
Travis	44	2	52	0	32	1	19	1	193	5	11	0	88	2	7	0	83	0	7	0
Cody	35	1	30	2	10	0	18	0	3	0	5	0	2	0	5	0	1	0	0	0
Fremont	24	1	0	0	24	0	3	2	46	0	2	0	39	0	2	0	56	0	3	0
Lewis	30	1	5	0	138	10	6	3	131	1	15	1	29	0	9	0	33	0	11	4
Total	3,536	123	388	81	1,388	38	185	36	1,389	24	255	10	939	45	292	13	920	30	94	10

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

An inspection of this table shows that in any given camp the admissions for measles bear no exact relation to the incidence of empyema. Neither does the number of recorded postmeasles empyemata vary with much precision in conformity to the variations in the number of admissions for measles nor conform to those of measles complicated with pneumonia. Though these numbers usually increase or decrease at the same time, the extent of the upward or downward excursions taken by each is often markedly different, and in many instances they are in the opposite directions.

Turning to the totals for each month, in order to eliminate as far as possible fortuitous discrepancies likely to occur in single localities, a progressive increase in the number of empyemata as compared with the number of measles cases is revealed. Starting in October, the empyemata are less than 1 per cent of the measles, but by April the ratio has risen to over 30 per cent. If the series were carried further through the year there would come a time when the number of empyemata exceeded the total number of measles cases. At the time of highest incidence of measles, the total for empyemata was 1.5 per cent of the measles and the recorded postmeasles empyemata 0.46 per cent. The largest number of postmeasles cases was in December and the highest rate in February.

It is clearly evident from these tabulated figures that measles plays no direct part in determining the incidence of empyema in the sense that the latter is a natural sequela of measles. That it may be a contributing cause when other conditions prevail can not be either established or disproved by a simple array of figures such as these, but is suggested by the fact that in many instances the postmeasles cases increase in number with an increase of measles. Whether these fluctuations exceed the probabilities deducible from the doctrine of chance can not be stated. There is no relationship so clearly revealed by this table that it can be stated in simple terms.

By referring to Table 3, it will be seen that a tabulation of influenza and empyema cases reveals no obvious and simple relationship between the two. Since the proportion of cases followed by empyema is too small for such a conclusion, empyema can not be regarded as one of the natural sequelæ of influenza in the sense that infection of the pleura leading to suppuration is a definite part of its pathology. One is forced to search elsewhere for more satisfactory causes predisposing to the development of empyema.

Bacteriological examinations of empyema fluids revealed the presence of organisms commonly associated with suppurative or at least exudative inflammations in other regions in substantially all cases. The organisms most usually found are pneumococci, streptococci, and staphylococci. More rarely the influenza or tubercle bacillus, or bacillus mucosus capsulatus were encountered. There were many instances in which two or three bacteria were found in the fluids obtained at the first diagnostic aspiration.

TABLE 3.[a]—*Incidence of influenza and of empyema. Absolute numbers.*

[NOTE.—The number of cases definitely recorded as being postinfluenzal are given in parentheses.]

Camps.	1918.									
	August.		September.		October.		November.		December.	
	Influenza.	Empyema.	Influenza.	Empyema.	Influenza.	Empyema.	Influenza.	Empyema.	Influenza.	Empyema.
Devens	26	2	9,329	52 (27)	1,040	2 (2)	32	6 (2)	121	4 (3)
Upton	24	0	3,033	5 (3)	2,226	13 (4)	523	5 (2)	124	3
Meade	50	0	7,465	11 (11)	5,929	22 (13)	199	2	95	4
Lee	24	0	7,148	1 (1)	5,372	0	185	0	628	0
Greene	18	0	228	2 (1)	3,998	15 (10)	102	0	75	1 (1)
Hancock	46	0	1,296	4 (3)	6,813	25 (24)	206	6	118	2 (2)
Sevier	17	0	2,211	2 (2)	3,673	1 (1)	156	0	105	0
Wheeler	155	3 (1)	142	0	389	5 (1)	108	6 (3)	26	0
Gordon	267	6	745	25 (17)	151	12 (3)	11	0	4	2
McClellan	12	0	170	1 (1)	5,204	20 (11)	294	3	76	3 (1)
Sherman	22	2	1,725	22 (9)	4,620	73 (38)	53	4	27	2
Custer	17	2	1,089	8 (4)	6,551	76 (56)	68	5 (2)	7	7 (1)
Grant	8	2	5,798	29 (36)	3,284	50 (39)	100	4 (4)	149	5 (1)
Dodge	39	8 (2)	757	15 (9)	9,734	105 (96)	492	8 (1)	317	4 (1)
Pike	77	4	6,560	34 (19)	5,717	55 (31)	200	4	95	11 (2)
Shelby	260	2	679	1 (1)	1,730	7 (6)	315	5 (5)	94	1
Beauregard	26	0	3,520	11 (8)	2,356	13 (9)	98	0	24	0
Logan	97	0	2,238	10 (9)	2,018	5 (2)	220	0	180	0
Bowie	6	0	766	1	3,325	12 (8)	136	4	39	1
Travis	230	2	301	1	10,194	20 (17)	570	1 (1)	953	0
Cody	25	1 (1)	16	0	2,178	17 (17)	525	9 (7)	28	0
Fremont	3	0	9	0	526	2	16	0	8	1
Lewis	401	0	582	4 (1)	3,029	12 (10)	657	1 (1)	160	4 (1)
Total	1,850	34	55,807	239	90,057	562	5,266	73	3,453	55

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

A natural inquiry would be the relative frequency with which these groups of organisms occurred in relation to the total numbers of empyema cases at intervals during the epidemic. Table 4 gives by months the total number of empyema cases recorded for the 23 camps included in the map, the number of positive bacteriological reports, and those reports which showed streptococci and pneumococci.[7] Since it is not easy to comprehend the significance of this table, these data have been plotted as shown in Chart II.

TABLE 4.[a]—*Comparison of the microorganisms in pleural exudates.*

	Empyema.	Positive reports.	Positive reports—Percentage.	Streptococcus group	Streptococcus—Percentage of total.	Streptococcus—Percentage positive reports.	Pneumococcus.	Pneumococcus—Percentage of total.	Pneumococcus—Percentage positive reports.
1917.									
October	24	10	41.6	4	16.6	40.0	6	25.0	60.0
November	168	68	40.5	25	14.9	36.7	43	25.6	63.3
December	387	202	52.2	116	30.0	57.4	86	22.2	42.6
1918.									
January	388	254	65.4	179	46.1	70.5	75	19.3	29.5
February	186	137	73.6	102	54.8	74.4	35	18.8	25.6
March	255	193	76.1	179	70.6	92.7	14	5.5	7.3
April	292	228	78.1	191	65.4	83.8	37	12.7	16.2
May	94	67	71.3	56	59.4	83.6	11	11.5	16.4
June	29	27	93.0	18	62.0	66.7	9	31.0	33.3
July	22	19	86.3	11	50.0	57.8	8	36.3	42.2
August	34	26	76.4	13	38.2	50.0	13	38.2	50.0
September	239	190	79.5	108	45.2	56.8	82	34.3	43.2
October	562	423	75.3	243	43.3	44.3	180	32.0	55.7
November	73	54	74.0	40	54.8	74.1	14	19.2	25.9
December	55	36	65.5	28	51.0	77.8	8	14.5	22.2
	2,808	1,934	68.8	1,313	46.7	67.9	621	23.0	32.1

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

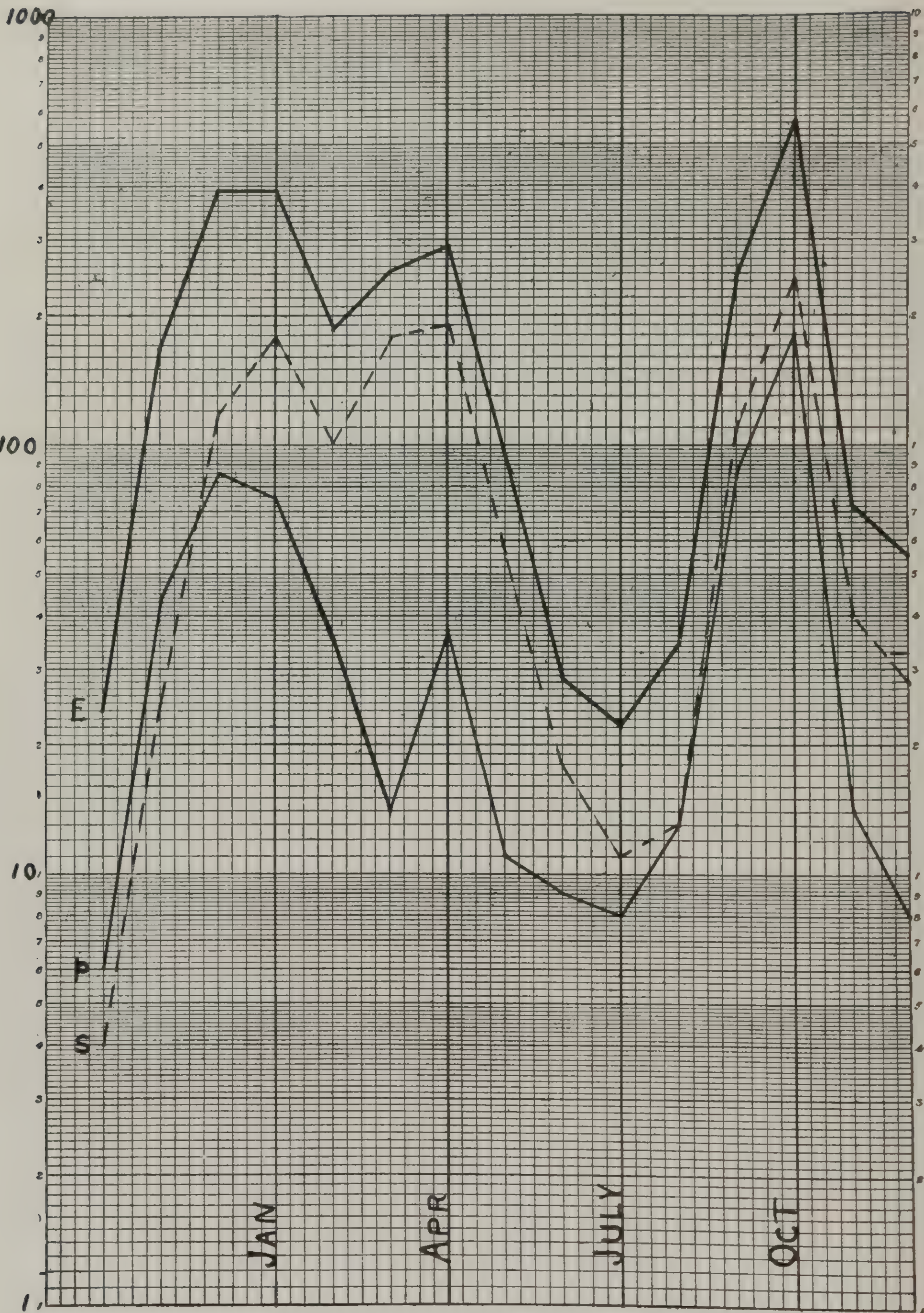


CHART II.—Empyema in Army camps and cantonments with pneumococci and streptococci isolated from the exudates. Absolute numbers on a logarithmic scale.

Chart II brings out a very striking parallelism between the cases of streptococcus empyema and the total number of empyema cases. The pneumococcus cases pursue a more independent course. As a matter of fact, between November, 1917, and April, 1918, the majority of the empyemata were the result of streptococcus infection. After this, there is a marked recession until August, when the percentage of streptococcus cases again increases. In contrast to this, the pneumococcus curve recedes after November, 1917, with a sudden decrease in

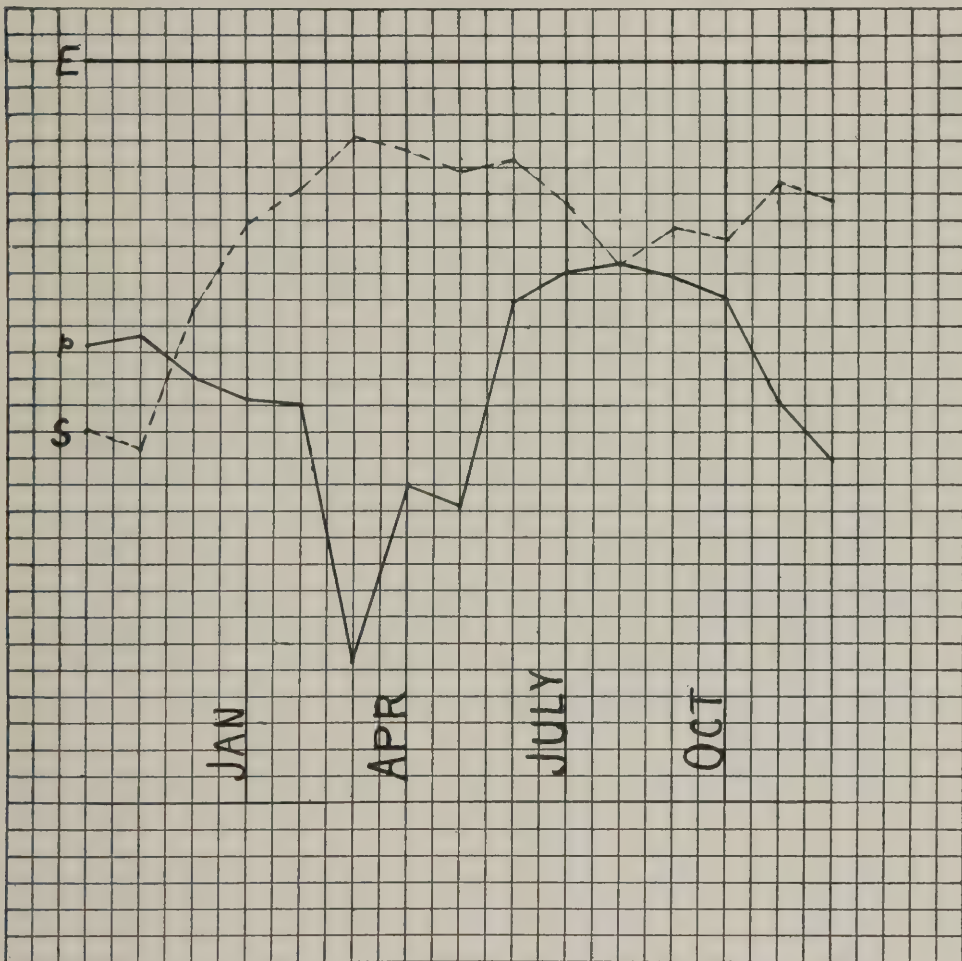


CHART III.—Arithmetical chart further illustrating Chart II.

March. After April the number of pneumococcus infections increases, and from June until October pneumococci play a more prominent part than at any previous time. After this there is a rapid decline in the proportion of cases associated with this organism. The relations just described are better illustrated in Chart III, where the empyema curve, shown in Chart II, is represented by a straight line and the distances between it and the streptococcus and pneumococcus empyemata are plotted to form simple arithmetical curves. The abrupt rise shown by the pneumococcus curve during April coincides with an

outbreak of influenza in the camps at that time just as the still greater rise in September and October coincides with the pandemic of that disease.

To pursue the thread of this inquiry, it is necessary to discover the sources of those organisms which have been shown to be most frequently associated with empyema. The pneumococcus is present in the lungs in the vast majority of cases of lobar pneumonia, as well as those not conforming strictly to the typical forms of lobar pneumonia. The streptococcus is also known to be present in many varieties of pneumonia, but particularly in the bronchial types. In either case the portal of entry is through the upper respiratory tract. It is well known that streptococci frequently find lodgment in the throat and induce pharyngitis, or tonsillitis. They may persist in these parts without inducing noticeable symptoms. Healthy carriers of organisms of this group are not very uncommon, particularly when people are thrown together in close association. There are abundant reports in the literature demonstrating this fact.

These considerations suggest the importance of studying the relations between empyema and infections of the upper respiratory tract. Infections which fail to produce symptoms could be detected only by bacteriological surveys, which were not systematically made.

Table 5 contains the total respiratory diseases, including influenza, for the 23 selected camps lying in different parts of the United States. Pneumonia and empyema also are given. The percentages of empyema with respect to other respiratory diseases and to pneumonia are found in the last two columns. It is apparent from these percentages that the incidence of empyema bears a more nearly constant relation to infections of the upper air passages than to pulmonary infections. This does not, however, necessarily imply that a pneumonia does not enter into the history of individual cases of empyema. In fact, this is almost invariably the case. But the deduction suggested by these calculations is that whether a given pneumonia is or is not to be complicated by empyema depends to some extent upon the existence and character of a preceding infection of the upper respiratory tract.

TABLE 5.[a]—*Relations between pneumonia and other respiratory diseases and empyema, 23 Army camps.*

	Pneumonia.	Other respiratory diseases.	Empyema.	Per cent of pneumonia.	Per cent of other respiratory diseases.
1917.					
October	533	4,855	24	4.5	0.49
November	1,620	14,827	168	10	1.12
December	1,926	24,567	387	20.1	1.57
1918.					
January	2,026	26,825	388	19.15	1.67
February	1,228	16,960	186	15.14	1.1
March	1,284	22,112	255	19.86	1.15
April	1,565	32,311	292	18.6	.9
May	799	11,593	94	11.76	.81
June	525	6,233	29	5.52	.46
July	475	6,156	22	4.63	.36
August	851	7,478	34	4	.45
September	2,997	65,048	239	7.98	.37
October	6,077	99,673	562	9.25	.56
November	1,207	10,301	73	6.05	.71
December	776	11,983	55	7.1	.47

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

If the above deduction were supported by a more detailed study, it would have an important bearing on the preventive measures likely to reduce the occurrence of empyema and would tend to avert the very serious disabilities following this disease.

STUDY OF DATA FROM EACH OF TWENTY-THREE CAMPS.

Because combined statistics such as the foregoing give totals only, and these may mask individual departures from the average that may be of importance, it is desirable to study separately each of the camps contributing to these totals. The following pages are devoted to this study.

In the tables and graphic charts included in this section, the data concerning pneumonia and common respiratory diseases have been obtained from monthly reports of sick and wounded to the Office of the Surgeon General, United States Army. The data concerning the incidence of empyema and the associated bacteria are derived from the special empyema records described in Chapter I of this section. They also are expressed in monthly ratios per thousand men, but the absolute numbers are given in addition so that the number of cases upon which those ratios are based and the incompleteness of the bacteriological data may be seen. Where information supplementing that contained in the special empyema records was available, it has been used. Such information was sometimes furnished by replies to the questionnaire concerning empyema which was sent to military hospitals by the Surgeon General on February 21, 1919.[8] It has not always been possible, however, to compare accurately the data in these replies with those in the special empyema records. There are two reasons for this. First, the replies were frequently in percentages rather than in absolute numbers. Second, cases which had not developed empyema at the time the replies were prepared could be included, but empyema cases included in the special empyema records were always referred to the date of admission for the primary disease irrespective of the interval between that date and the development or recognition of the empyema. Since the dates of transmission of the replies are the only dates given, it has been impossible, particularly when empyema cases were numerous, to know just what cases were common to both sources of information. The replies relate only to those which occurred in the fall of 1917 and the early months of 1918.

For additional facts regarding cases, particularly in the later months of 1918, valuable information has been obtained from reports published in current medical journals. Where these were available and contained statistical data, they have been freely used.

There is at least one known element of incompleteness in the data contained in the special empyema records, which it has been impracticable to avoid. This arises from the fact that empyema is a secondary or complicating disease in substantially all instances. Unless a given case was transferred from the medical to the surgical service of a hospital, the occurrence of empyema was likely to be noted only as an incident in the clinical history and this, when filed, was indexed under the primary disease for which the case was admitted to the hospital. If, however, the case was transferred to the surgical service for the treatment of empyema, it would there be classed as such and so indexed in the files.

It follows from this that the special empyema records probably include substantially all cases coming to operation and transferred to surgical wards but probably do not include many cases which were never transferred. Empyemata, first recognized at autopsy, have undoubtedly been frequently omitted. Clinically unrecognized cases on which no post-mortem was held would, of course, remain unknown. There can be no doubt of the actual existence of such cases but their number can not be estimated.

In grouping the bacteriological findings into three broad classes—pneumococcus, streptococcus, and staphylococcus—some liberty has been taken which may have served to exaggerate to a slight extent the number of cases associated with streptococci. Some—probably many—of the bacteriological reports [9] were based on the microscopical examination of a stained streak or smear of the exudate without the preparation of cultures. This resulted in such inconclusive diagnoses as "diplococci" or "Gram-positive" cocci, or diplococci. These might actually have been pneumococci or streptococci, or even, in some instances, staphylococci. They have been placed in the streptococcus group. The justification here advanced for this is that in many cases—in probably the majority—certain streptococci, particularly hemolytic streptococci, fail to appear in chains when a pleural exudate is examined morphologically soon after withdrawal from the chest. They appear as diplococci, with the adjacent sides slightly flattened. Sometimes two to four such diplococci will be in juxtaposition, but this often appears to be fortuitous, and a positive diagnosis of streptococcus would be deemed hazardous. Their appearance differs considerably from that of the capsulated, lanceolate, diplococcus forms constituting the classical picture for the pneumococcus. It appears highly probable that the term "diplococcus" was used to describe the organism as being safer than to venture upon a more specific designation in the absence of appearances clearly indicating that they were pneumococci. However this may be, the instances of such inconclusive diagnoses are not numerous, and to include all among the streptococci, where doubtless the majority of them actually belong, can not seriously affect the statistics.

The pneumococci obtained from pleural exudates have been typed so rarely that no useful purpose would be served by attempting to classify the findings in this respect in the tables given in this chapter.

In view of all the foregoing considerations, it has appeared most instructive for present purposes to classify the bacteriological findings into the three broad groups adopted, trusting that the mass of the statistics would minimize incidental inaccuracies.

Finally, it should be stated that the empyemata included in these tables and charts are those originating in the respective camps. Transferred cases are excluded because they throw no light upon epidemiological questions.

The charts give in graphic form the relations between the ratios per thousand men contained in the tables. These data have been plotted on paper ruled for the logarithms of the actual figures. This logarithmic scale has been used because a comparison of the curves so plotted is particularly instructive. If any portions of two curves are parallel, it shows that the figures represented by those portions are in the same ratio to each other, and the vertical distance between the curves gives that ratio. For example,

the chart for Camp Devens shows a much closer parallelism between the curves "E" and "R" than that between "E" and "P," showing that in this camp there was a more uniform relation between the incidence of empyema and infections of the upper respiratory tract than between empyema and the pneumonias. The actual figures are given by the small numerals at the side of the chart. These are arranged in four similar banks, each bank being 10 times that of the one immediately below. As used, the first bank represents hundredths (i. e., ratios of 0.01 to 0.09 per thousand men), the second bank tenths (0.1 to 0.9 per thousand men), the third bank units (1 to 91), and the fourth tens (10 to 99). Occasionally the figures are greater than 100, and therefore the curve runs off the ruled portion of the chart. In such instances this part of the curve has been calculated to conform to the scale. The curve marked "R" represents the total respiratory diseases less the pneumonias. It includes, therefore, all forms of influenza and common respiratory diseases, such as tonsillitis, pharyngitis, laryngitis, and bronchitis, if of sufficient severity to entail admission to the hospital. The pneumonias (lobar and bronchopneumonia) are represented by the curve "P." The monthly ratios per thousand have been used for convenience in plotting. Had the annual rates been used, the curves would have exceeded the bounds of any available paper. This method does not in any way change the character of the curve and is in exact accord with the mode of calculating the ratios given for empyema and associated bacteria.

CAMP DEVENS.

Camp Devens, Mass., was situated on the outskirts of Ayer, a town of about 3,000 inhabitants, 30 miles from Boston. [10]

Drafted men from New England and part of New York were assembled here. [10] The urbanity for the whole territory was 63.7 per cent. [10]

Frame barracks were used as quarters for the troops. [10] The strength of the command reached 28,000 men by December, 1917, all white. [10] The first contingent of 2,184 men arrived between September 5 and 10. [10]

Infectious diseases were of low incidence in the fall of 1917, measles being largest in number, reaching a total of 201 cases for the last four months of that year. [11] They were most numerous in the quarters most crowded, but were of mild type and generally uncomplicated, only one case of lobar pneumonia being reported. This occurred in December, when the incidence of measles was at the highest point for that year, 166 cases being admitted to the hospital. The following month the admissions rose to 245, but fell to 49 the next month and never exceeded 88 in any subsequent month. [11]

From the start the camp was always overcrowded. [10] The accommodations were designed for approximately 35,000 troops, but the number often exceeded this, reaching at one time 45,000 (September, 1918). [10] Despite this congestion the admissions for infectious diseases were relatively few. This may be owing to the high proportion of men from urban homes. The comparatively small influx of troops from distant parts of the country may have had some influence also.

According to the special empyema records, the first case to develop empyema was admitted to the hospital December 29, 1917, for measles. [12] Lobar pneumonia developed in the left upper lobe on the twenty-second day

after admission, and empyema on the left side was noted four days later. The empyema was treated by thoracotomy and drainage on the day it was recognized. Streptococci were found in the discharge. This case was further complicated by abscesses about the rectum, in the sacral and gluteal regions, in the rectus abdominis, and in the left shoulder, apparently involving the joint. Death occurred March 4, 1918, 65 days after admission to the hospital. The post-mortem revealed a septic infarct in the upper lobe of the right lung, with acute fibrinous pleuritis on that side. On the left side there was an undrained pocket containing 200 c. c. of pus in the lateral upper portion of the pleura, in addition to the drained cavity below. Smears from the right rectus sheath contained streptococci.

In addition to the foregoing, there were four cases of empyema following true measles and one following rubella. [12] These all occurred prior to March, 1918, and were associated with streptococci. Two died, 12 and 52 days after admission. The remaining three were returned to duty after 44, 113, and 151 days in the hospital. It is worthy of note that two of these five cases suffered from acute follicular tonsillitis within a short time after admission. It is also noteworthy that five other cases not associated with measles were admitted to the hospital for acute infections of the throat prior to May, 1918—three for follicular tonsillitis and two for pharyngitis. The pleural exudates in all these cases, with a single exception lacking a record of any bacteriological examination, contained streptococci.

With the advent of epidemic influenza, the number of cases of empyema increased rapidly. In all, 41 cases are associated with this disease in the special empyema records, with 8 deaths.[12] The presence of streptococcus is less marked in this period than in the earlier period of high incidence, in the fall of 1917 and early in 1918.

The figures given above and in the tabulation to follow do not correspond precisely to those obtained through other sources.

In the reply dated February 27, 1918, to the questionnaire of February 21, 24 cases of empyema were reported, among which 11 died.[9] The special empyema reports include only 11 cases, with 1 death, prior to February 27. This is such a serious discrepancy that an inquiry into the reasons for its occurrence is important.

When the request for data concerning empyema was sent, on January 10, 1919, to military hospitals throughout the country, it could be complied with only by consulting the records preserved in the hospitals.[13] Many cases of empyema would inevitably be overlooked in searching these records.

Examining the above discrepancy, it appears that 12 of the 24 cases referred to in the reply were not operated, and that 11 of the 12 were fatal. On the other hand, all of the cases appearing in the special empyema reports were operated. If the unoperated cases just referred to are added to these, the total reaches 23, or only 1 less than the total given in the reply, but with a mortality of 12, instead of the 11 therein noted. The discrepancy becomes reduced to 1 case less, and 1 death more in the special empyema report as amended with data included in the reply to the questionnaire and collected by those themselves familiar with the cases while in the hospital wards. The additional death had not taken place at the time the reply was sent.

It will not be possible to detect such discrepancies as the foregoing in many of the reports from hospitals, for the data given in the replies to the questionnaire of February 21 are often expressed in percentages, without the absolute numbers upon which those percentages are based being stated. But it is well to bear in mind that cases of empyema not admitted to the surgical wards, either by reason of recovery without operation or because of death, are liable to escape classification as empyema and in consequence fail to be included in the special empyema reports. The data concerning incidence and other questions of epidemiological importance furnished by these records must be regarded as minimal rather than actual.

Returning to the data furnished in the reply: In 23 of the 24 cases, a bacteriological examination of the pleural fluid was made. In 15, or 70 per cent, streptococcus alone was found; in five, pneumococcus, and in the remaining two, staphylococcus associated in one instance with streptococcus. Two of the cases followed pneumonia secondary to some other disease (presumably measles). This would be approximately 8 per cent of the total number of empyema cases.

Another source of information concerning empyema at Camp Devens in the earlier period is furnished in an article by [14] a member of the local empyema team, created to study this disease in the base hospital, Camp Devens. The period covered is from September 27, 1917, to May 31, 1918, or 35 weeks, beginning at a time when the camp contained approximately 18,000 men.

There were 77 cases of empyema, of which 14 were preceded by measles, constituting 18.2 per cent of the whole number of empyema cases considered. The number of measles cases was 588, so that those which developed empyema were a trifle less than 2.4 per cent. The measles cases developing pneumonia were 41, or 7 per cent of all the measles cases, and of these, 34 per cent were complicated by empyema. This is a much higher proportion than that for primary pneumonia, which is given as 15 per cent. The bacteriological examinations of the postmeasles cases are not separated from those having other histories. The most frequent organism found in all 77 cases of empyema was a streptococcus alone in 53 per cent of the cases. Next most frequent was pneumococcus alone in 27 per cent, and the two in association amounted to 17 per cent. If the streptococcus is given precedence and this last figure added to the 53 per cent in which this organism occurred without admixture, the total number of cases in which the streptococcus was found amounted to 70 per cent, exactly agreeing with the figure reported in the reply to the questionnaire of February 21, already cited.

There is still another clue to the relative part assignable to the streptococcus in the empyemata at different periods. In the published article referred to [14] there were 9 cases of empyema among negroes, in which the streptococcus was present in 4, the pneumococcus alone in 5. Among the contemporary white troops there were 15 cases of empyema in which the streptococcus either alone (4 cases), or associated with pneumococcus (8 cases) was found in 12, or 80 per cent. These cases must be assigned to the months of April and May since the number of negroes in camp prior to April was negligible. Before this date there were 53 empyema cases among the white troops, 35 with streptococcus alone, three with admixture of pneumococcus, and 13 with the latter alone. These figures indicate that up to April a streptococcus was associated with approxi-

mately 72 per cent of the cases. There appears, therefore, to have been a very slightly increasing preponderance of the streptococcus with the progress of time from the autumn of 1917 to the spring of 1918. There was certainly no diminution in its relative frequency as compared with the pneumococcus. Nor is there any evidence that the postmeasles cases which were most numerous about the middle of this period were peculiarly prone to association with streptococci.

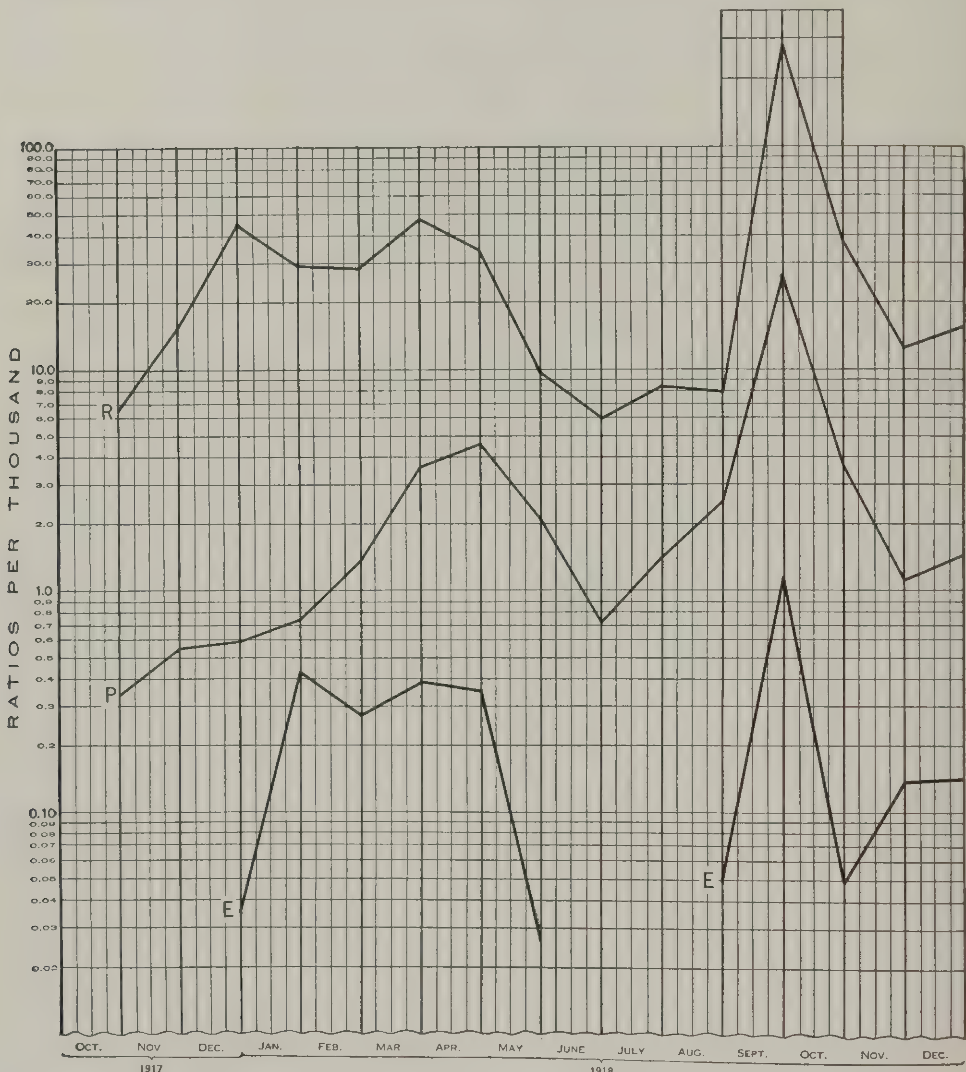


CHART IV.—Epidemiological chart for Camp Devens, Mass., in monthly ratios per thousand men.

The reduced significance of the streptococcus during the influenza epidemic as indicated in the special empyema reports is also emphasized by the bacteriological data published by Gage,[15] who contrasts the two periods. In the earlier group of 77 cases the streptococcus was present in 53, or 69 per cent; in the later group of 61 cases, in 26 per cent. The pneumococcus alone appears in 28 per cent of the first group, and in 45 per cent of the second.

The statistical material bearing upon the epidemiology of empyema at Camp Devens, drawn from the special empyema reports, is presented in Table 6 and Charts IV and V. On the latter, all the data are presented in terms of ratios per 1,000 men in camp, based upon the average strength for the corresponding month.

The general impression conveyed by Chart IV is that the incidence of empyema bore a closer relation to the admissions for upper respiratory diseases than to those for pneumonia, particularly in the early months of 1918. It is noticeable

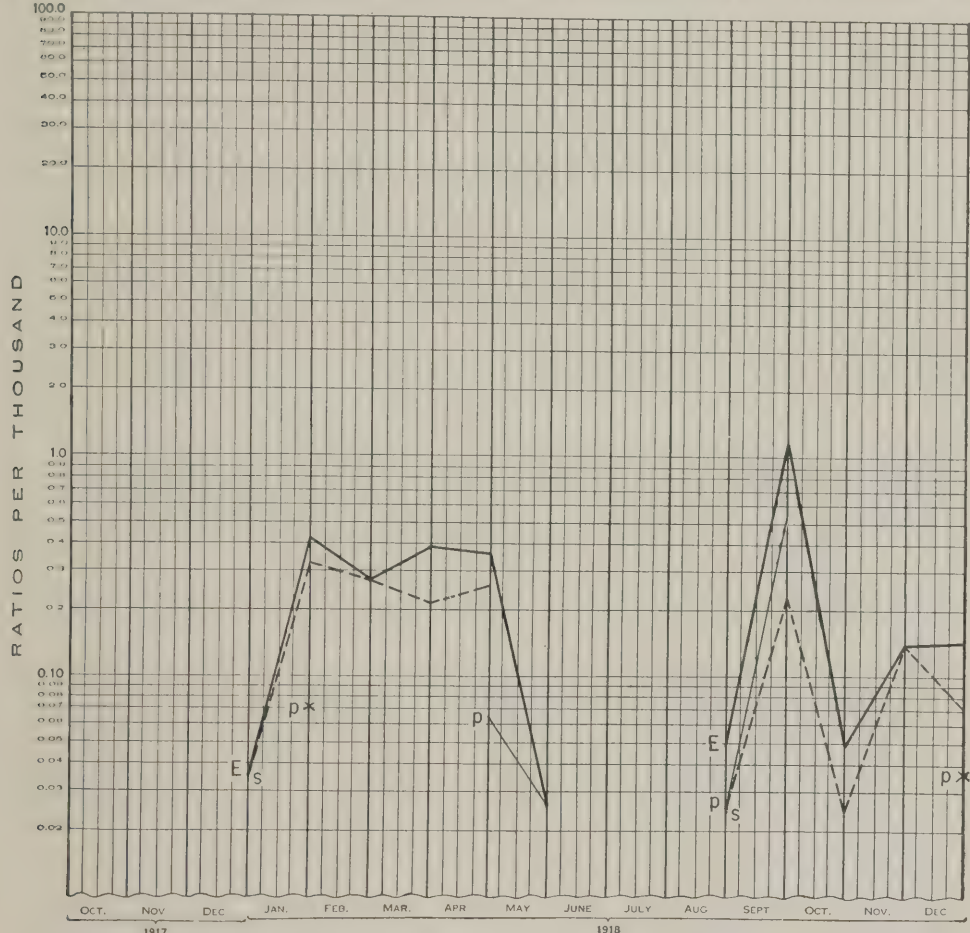


CHART V.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Devens, Mass.

that when the curve "R" falls distinctly below the ratio of 10 per thousand men, i. e., 1 per cent, there are no cases of empyema, and when the curve "R" is at the level of 1 per cent, in May, 1918, the single case of empyema was associated with pneumococcus, while before that time, streptococci predominated.

Turning now to the curve "P" representing admissions for primary pneumonias, these were at approximately the same level in January, 1918, when the incidence of empyema was maximum, as in June of that year when no cases of empyema were reported.

The relationship between the pneumonia and empyema curves does not display such divergences during the pandemic of influenza, but it is worthy of remark that in the beginning of this period the pneumococcus was closely related to empyema, the curves for this organism being exactly parallel to the empyemata between September and October, and that the streptococcus did not acquire great relative prominence until after the epidemic had subsided. The fact that the pneumococcus played the most dominant part in the empyemata at this time may perhaps be correlated with the fact that among the pneumonias nearly six out of seven were of the lobar variety.

TABLE 6.[a]—*Epidemiological table for Camp Devens, Mass.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917											
October	0	0	0	0	0	0.33	6.42	0	0	0	0
November	0	0	0	0	0	.55	15.72	0	0	0	0
December	1	1	1	0	0	.59	45.61	0.0346	0.0348	0	100
1918											
January	12	0	9	2	0	.75	29.05	.4285	.3214	0.0714	0
February	7	3	7	0	0	1.36	28.65	.2703	.2705	0	43
March	11	4	6	0	0	3.56	47.57	.3880	.2117	0	36
April	11	2	8	2	0	4.51	34.31	.3550	.2569	.0642	18
May	1	0	0	1	0	2.10	9.77	.0262	0	.0262	0
June	0	0	0	0	0	.72	5.98	0	0	0	0
July	0	0	0	0	0	1.41	8.31	0	0	0	0
August	2	0	1	1	0	2.50	7.91	.0499	.0252	.0252	0
September	52	20	10	25	0	26.81	282.39	1.1477	.2207	.5578	39
October	2	1	1	0	0	3.63	37.18	.0487	.0243	0	50
November	6	2	6	0	0	1.13	12.33	.1399	.1398	0	33
December	4	0	2	1	0	1.47	15.88	.1409	.0705	.0353	0
	109	33	49	32	0	....	....	....	....	....	30.3

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP UPTON.

Camp Upton was about 5 miles from Yaphank, a small village on Long Island, N. Y., 65 miles from New York City.[10]

Drafted men from Greater New York were the first increment received, approximately 2,000 arriving between September 1 and 15.[10] By the end of October the number had increased to about 30,000.[10]

Frame barracks served as quarters.

The incidence of infectious diseases, excluding those of venereal origin, was low. There were only 51 cases of measles during the latter part of 1917, and the highest number of admissions to hospitals for this disease was in July, 1918, when 63 cases were admitted. The monthly average for that year was 28.[11]

Five cases of empyema following measles are on record; [12] two occurred in December, 1917, two in March, 1918, and one in June. Three of these post-measles cases were associated with hemolytic streptococci, and two were apparently sterile. Of these five cases, two died; one with sterile fluid, and one with hemolytic streptococci in the exudate. The latter had bilateral empyema. The other fatal case had pneumococcus, Type III, in the sputum, but the pleural fluid yielded no growth in culture, and at autopsy the case proved

to have general miliary tuberculosis as well as lobar pneumonia and empyema on the left side. The total number of measles cases for the camp was 386 for the three last months of 1917 and the whole of 1918.[11] The percentage of those developing empyema was therefore 1.3 per cent.[12]

Mumps preceded two cases of empyema, one in February, and one in March, 1918.[12] Both were associated with hemolytic streptococci. One convalesced; but the other died two days after recognition of the empyema, a fibrinopurulent pericarditis being found at autopsy. The preceding occurrence of mumps in these cases appears to have little significance, for there were 1442 cases of mumps in the camp up to the end of 1918.[12]

In March, 1918, in one case empyema followed scarlet fever.[12] The sputum contained hemolytic streptococcus, but the pleural exudate was reported sterile. This case appears to have recovered without operation.

The data from Camp Upton contained in the special empyema reports include many cases transferred from elsewhere or who had contracted the precedent disease while away from camp on furlough. The transferred cases were either from other military organizations in the United States or from overseas, this camp being used as an embarkation and debarkation camp after the 77th Division was moved overseas about April, 1918.[10] The transferred cases are eliminated from consideration in this chapter, which is confined to cases arising in the camp itself. This elimination reduces the number of empyema cases in the special empyema records very considerably.

It is fortunate, however, that another source of information is available for Camp Upton prior to the departure of the 77th Division. "A Study of Eighty Cases of Empyema at Camp Upton," published by Brooks and Cecil,[16] contains data concerning 59 cases unfortunately omitted from the special empyema reports when these were compiled from the records of the base hospital many months after the period embraced by that article. The data used here are combined from these two sources, transferred cases being omitted.

There is no record of empyema during September, October and November, 1917, but in December, 10 cases, that subsequently developed empyema, were admitted to the hospital.[12]

The first case was admitted for measles on December 6, but did not develop empyema until nearly eight weeks later, on January 27. Resection was done and a sterile exudate obtained, though the sputum had yielded pneumococcus, Type I, previously. This case recovered.[12]

The second case was severe in character, empyema being noted December 15, and death taking place on the 29th. At autopsy, an interstitial bronchopneumonia, with multiple pulmonary abcesses, was found with an empyema on the left side. The pus contained streptococcus viridans. Pneumococcus, Type II, had previously been obtained from the sputum.[12]

One case, in which staphylococcus aureus was found in the pleural exudate, was admitted December 22 with a primary pneumonia.[12] Pneumococcus, Type IV, was present in the sputum. Empyema appeared January 20, and death supervened February 11. There is no record of an autopsy. With this exception, and the case of miliary tuberculosis already mentioned, all the five fatal cases were associated with streptococcus, two with viridans and one with hemolyticus. Of the five surviving cases, the pleural fluid either contained pneumococcus (three), was sterile (one), or not recorded (one.)

The total number of empyema cases developing within the hospital was 107.[12] Of these, 48 died, a case mortality of 45 per cent. Of 87 cases, 65 (75 per cent) were associated with streptococcus, six with streptococcus viridans, and 51 with hemolytic strains, the specific character of the remaining eight being undefined. In addition, there was one case associated with staphylococcus aureus. This has already been briefly detailed. Of the 15 cases of pneumococcus empyema which were typed, eight were Type IV, four Type II

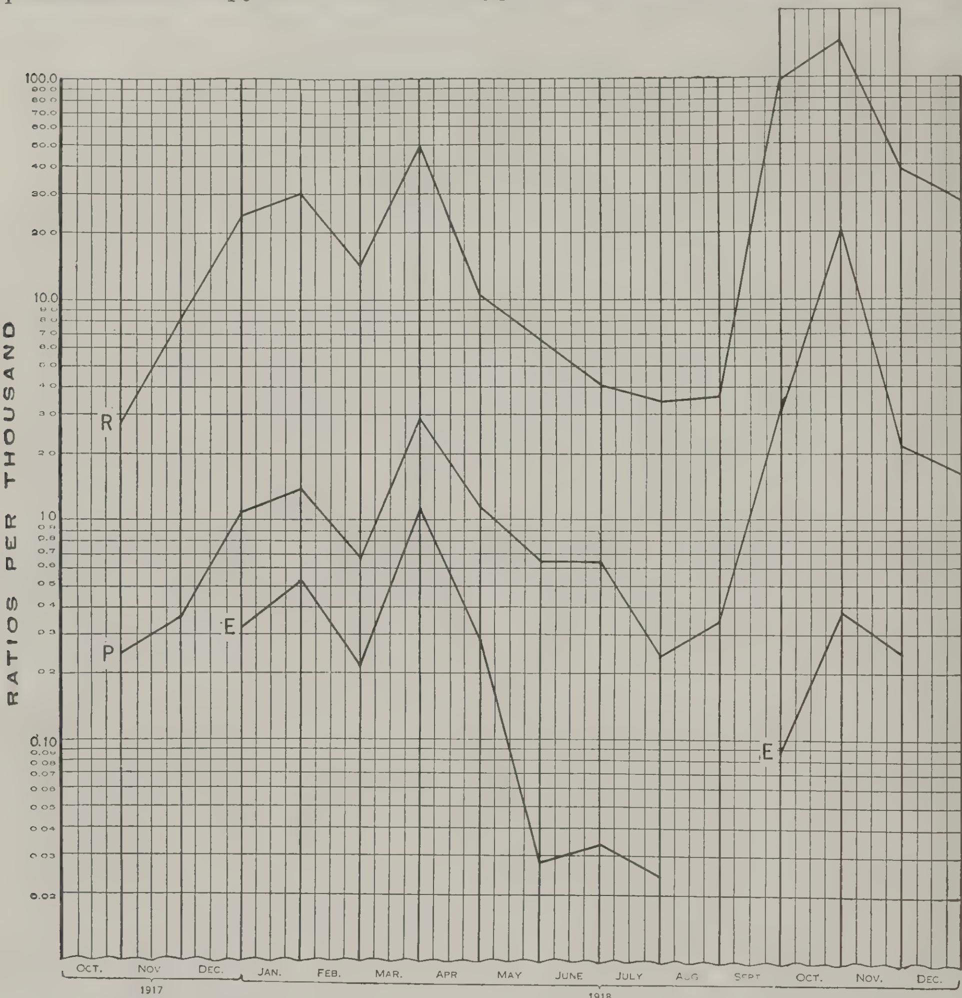


CHART VI.—Epidemiological chart for Camp Upton, N. Y., in monthly ratios per thousand men.

and three Type I. All of these 15 cases recovered. There were five deaths associated with pneumococcus; three of these were Type IV, the others Type II.

Table 7 and Chart VI give the relations between pneumonias and diseases of the upper respiratory tract, and Chart VII exhibits the associated microorganisms found in the pleural fluids. Chart VI, while differing considerably in detail from that for Camp Devens, presents several features of similar import. The general parallelism between the empyema curve "E" and "R" for the first few months is striking, although the curve "P" also closely conforms. There is the same exaggerated decrease of empyema when "R"

crosses the 1 per cent level, but not the complete extinction noted at Camp Devens. It seems as though during May, June, and July the influences determining the development of empyema persisted in a sporadic manner, giving rise to one case a month in fortuitous fashion. It is well to inquire into the character of these three cases. The first was admitted May 17 for lobar pneumonia in the lower lobe on both sides.[12] Nineteen days later a rib was resected and 20 c. c. of creamy pus yielding no growth on culture were evacuated. The wound was sutured about four weeks later and the patient was returned

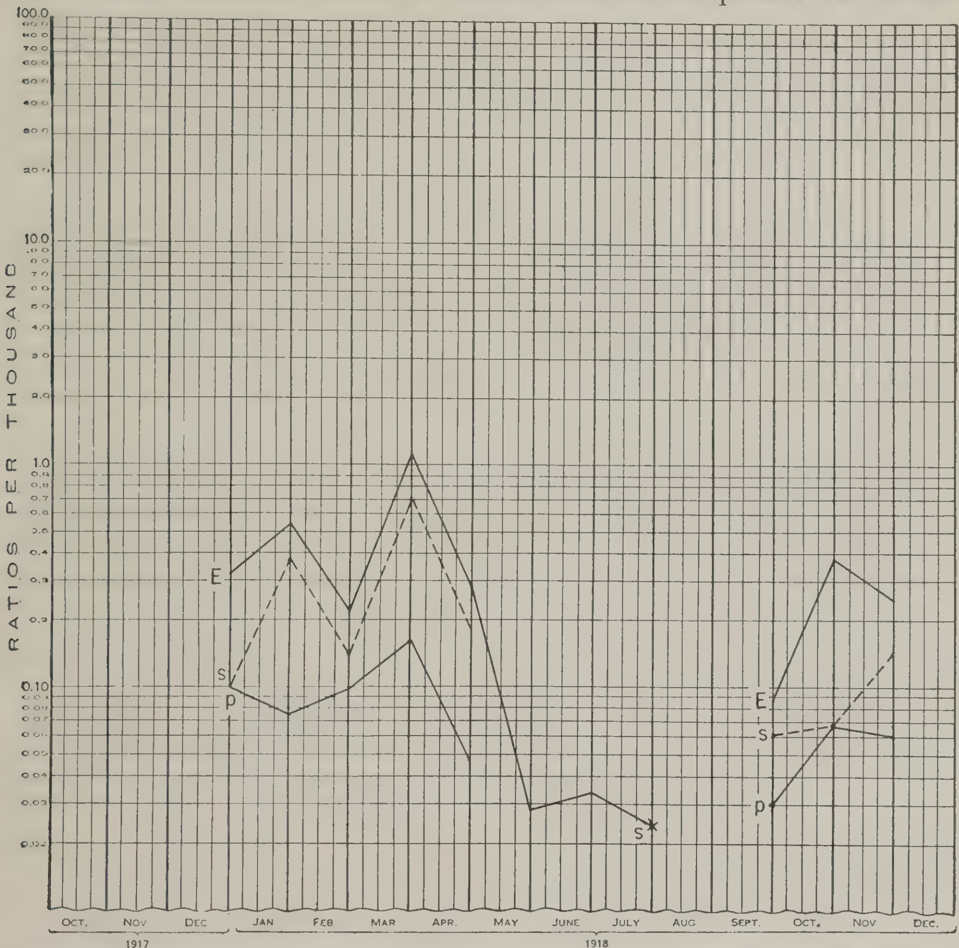


CHART VII.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Upton, N. Y.

to duty without any recorded complications. This history points to the probability of a pneumococcus infection overcome by natural processes, the operation promoting recovery through evacuation of a small residual pocket of pus. The June case was of a quite different character. The patient was admitted for measles, was operated (rib resected) 50 days later,[12] and ran a protracted course, being discharged from the Army on May 9, 1919, at General Hospital No. 12. There are no records of bacteriological findings. Finally, the July case was admitted for pneumonia on the 29th.[12] A rib was resected about three weeks later, about 150 c. c. of pus discharged, and an uneventful convalescence followed. Streptococci were found in the exudate.

There appears to be nothing of epidemiological interest in these cases. Two were mild cases, and all may be regarded as an aftermath of the preceding group of greater severity.

The curve of streptococcus, as shown in Chart VII cases, closely parallels that of the total empyema cases in the first period. This is not due to arbitrarily including doubtful diagnosis among the streptococci. There was only one record of "diplococcus" and this was in September, 1918. The prevailing streptococcus was hemolytic, but there were four cases associated with streptococcus viridans, all occurring in January, 1918. Of the pneumococci, 19 per cent were Type I; 25 per cent Type II, and 56 per cent Type IV. There was a considerable number of sterile fluids. Brooks and Cecil report 15 such among the 80 cases studied by them,[16] representing 18 per cent of the total. Seven died and only six are definitely reported as having operative treatment beyond aspiration. It is difficult to avoid the impression that a more careful study would have associated these cases with a definite infection of the pleura. They leave an unexplained hiatus in the records. A single autopsy in this group of sterile fluids revealed general miliary tuberculosis. This case has already been referred to (p. 67).

The bacteriological data of cases during the influenzal period are very meager.

TABLE 7.[a]—*Epidemiological table for Camp Upton, N. Y.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	0	0	0	0	0	0.25	2.81	0	0	0	0
November	0	0	0	0	0	.37	8.52	0	0	0	0
December	10	5	3	3	0	1.17	24.19	0.3343	0.1003	0.1003	50
1918.											
January	15	7	10	2	0	1.46	30.67	.5605	.3736	.0747	47
February	7	4	4	3	0	.69	15.93	.2290	.1308	.0982	57
March	40	20	25	6	0	2.98	49.89	1.1321	.7076	.1398	50
April	10	6	7	2	0	1.38	12.40	.2344	.1641	.0469	60
May	1	0	0	0	0	.68	6.79	.0273	.0	.0	0
June	1	0	0	0	0	.65	4.07	.0332	.0	.0	0
July	1	0	1	0	0	.24	3.60	.0257	.0257	.0	0
August	0	0	0	0	0	.35	3.72	.0	.0	.0	0
September	3	0	2	1	0	3.22	98.73	.0915	.0610	.0305	0
October	6	1	3	3	0	20.03	151.65	.3776	.0687	.0687	17
November	4	0	2	1	0	2.25	39.64	.2448	.1224	.0612	0
December	0	0	0	0	0	1.71	20.87	.0	.0	.0	0
	98	43	57	2.1	0	....	....	....	....	....	18.8

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP MEADE.

Camp Meade, Md., was situated a considerable distance from any large town, on rolling ground drained by sluggish streams.[10]

Drafted men were inducted into the National Army at this camp. They came from eastern Pennsylvania, Maryland, and the District of Columbia, a territory in which the inhabitants are 68.5 per cent urban. In November the strength of the camp averaged 31,000, including about 2,000 colored troops.[10]

Cases of communicable diseases were relatively few. Measles cases were most abundant in December, 1917 (113), and November, 1918 (161); the total number being 857 for the 15 months from and including October, 1917.[11] Eight cases of empyema, with five deaths, were associated with this disease, a little more than 0.9 per cent. It is noteworthy that none of these occurred in November, 1918, when the incidence of measles was maximum, but that two empyema cases fall in the month just preceding when the incidence of measles

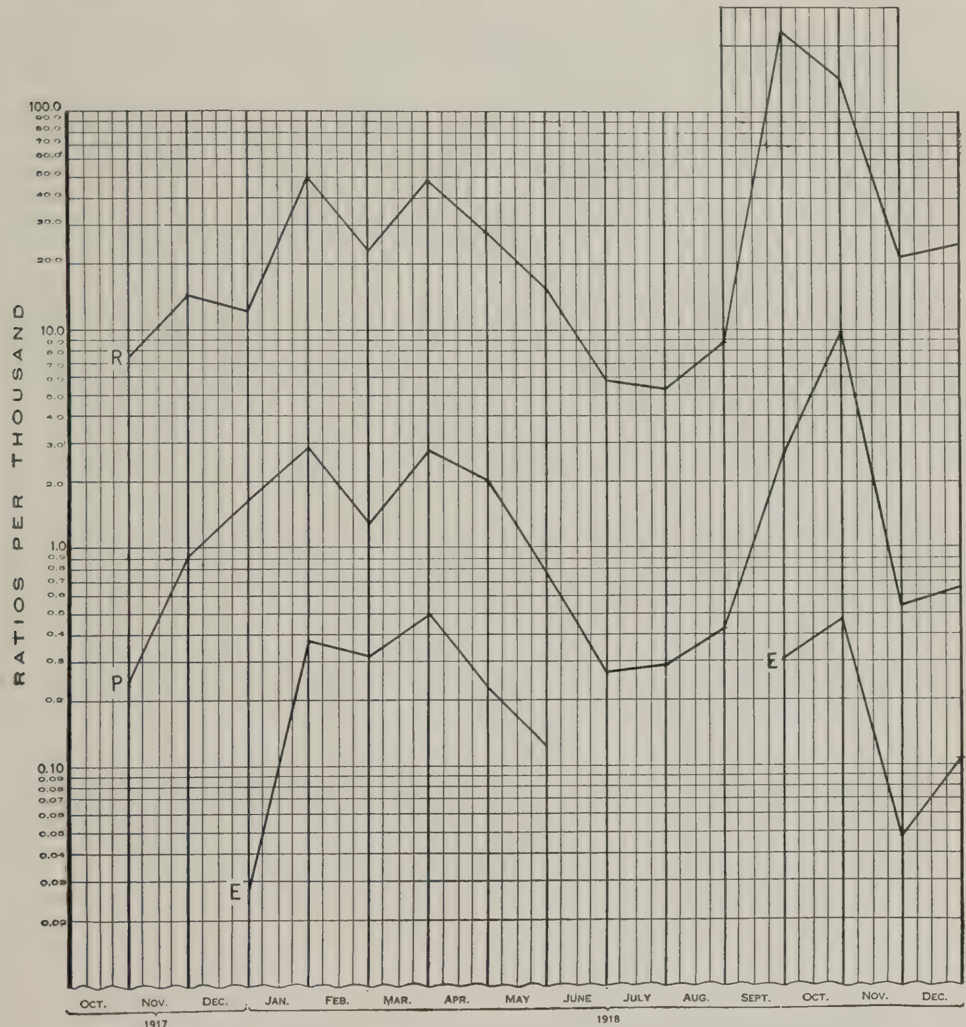


CHART VIII.—Epidemiological chart for Camp Meade, Md., in monthly ratios per thousand men.

was hardly more than one-third as great (55). Two cases of postmeasles empyema also occurred in March, 1919, when there were but 31 cases of measles. Bacteriological data are available in all but one of these empyema cases. With one exception, yielding pneumococcus, Type IV, they were all associated with a streptococcus, three definitely described as hemolytic, three undefined as to species.

Two cases of empyema were preceded by mumps, one in February and one in November, 1918. Both were associated with hemolytic streptococcus,

and both survived. The total incidence of mumps in camp during the period of 15 months was 897.[12]

Scarlet fever was followed by one case of empyema associated with streptococcus and proved fatal on the ninth day after admission.[12]

As happened so frequently elsewhere, the first case to develop empyema at Camp Meade followed measles. The date of admission of this case to the base hospital was December 29, 1917.[12] Lobar pneumonia in the right lower

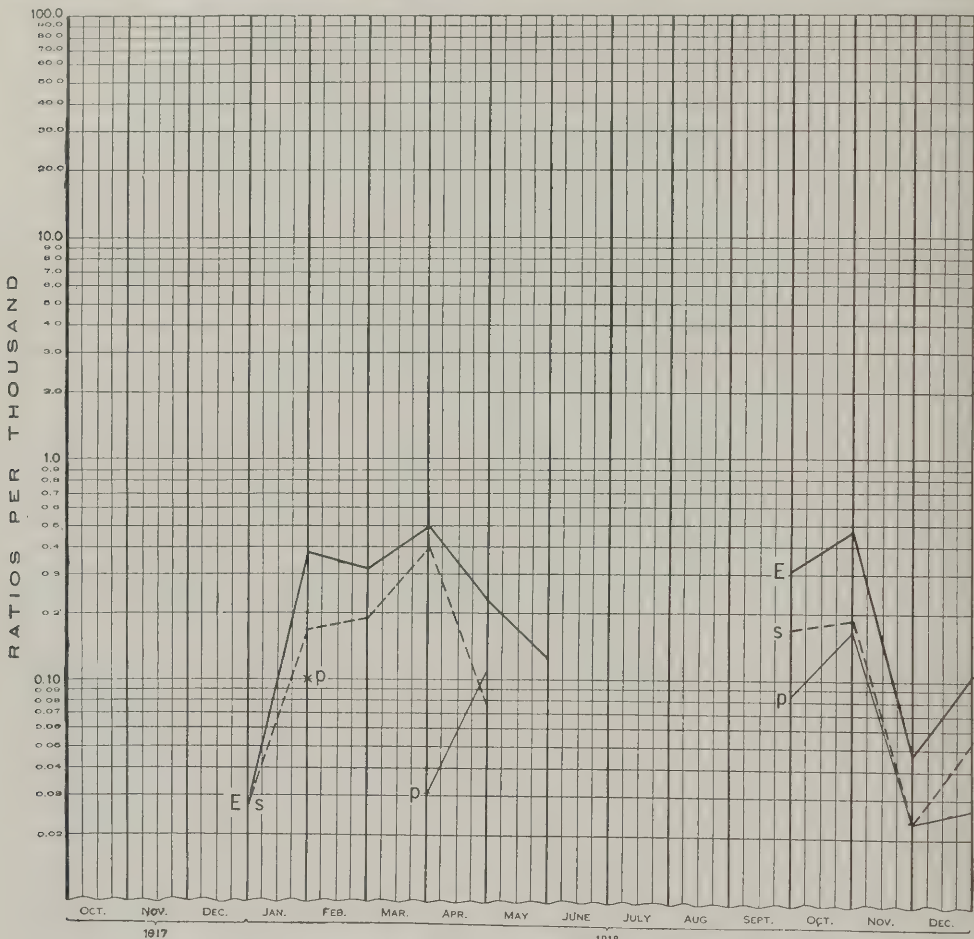


CHART IX.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Meade, Md.

lobe ensued 20 days later, followed by empyema for which a thoracotomy was done on the thirty-first day after entering the hospital. On April 14, 1918, half an inch of the eighth rib was resected and 300 c. c. of thick green pus containing hemolytic streptococci were evacuated. Postoperative treatment with Dakin's solution was instituted, but the wound did not close until nearly 100 days after this second operation. Complete recovery ensued without subsequent disability.[12]

The special empyema reports give a total of 87 empyema cases at Camp Meade during the latter part of 1917 and the whole of 1918.[12] Of these, 27 (or 31 per cent) died. Bacteriological examinations of the pleural exudate of 64 of these cases (74 per cent) were made, and of these, 70 per cent were streptococcus

and 27 per cent pneumococcus. One case was reported in May, 1918, as associated with staphylococcus. This patient recovered without marked subsequent disability. Finally, in one fatal case, occurring in October, 1918, the influenza bacillus alone was found. It is worthy of note that, during the first period of high incidence from December, 1917, to April, 1918, when there were 48 empyema cases, with a mortality of 20 (42 per cent), the streptococcus was found in the pleural fluids approximately four times as often as the pneumococcus, while in the later period of high incidence, with a mortality of 18 per cent, the proportion was 9.5, or somewhat less than half.

The curves for upper respiratory diseases, pneumonia and empyema all show a close similarity. The apparent irrelevancy of the pneumococcus in the first period and its prominence in the second are clearly shown. It is also noticeable that toward the end of the first period the pneumococcus rises in importance, while the streptococcus falls. This modification in the relative frequency of occurrence of these two organisms begins with that subsidence in the curve of common respiratory diseases leading without interruption to the minimum in July. There is no ambiguity in the bacteriological diagnoses from Camp Meade; but many cases were either not examined or the results of examination were not noted; otherwise, the curves representing the bacteria would have been closer to that of empyema.

It is particularly striking that the gap in the incidence of empyema, which separates the two periods, exactly corresponds to the drop of common respiratory diseases below 1 per cent of the men in camp. While, therefore, the pneumonias and other respiratory diseases remain in a nearly constant ratio to each other, there is some factor influencing the development of empyema which becomes inoperative when the incidence of the common respiratory diseases drops below a certain point. This point at Camp Meade and at Camp Devens is approximately 1 per cent of the command. At this point the evidence that streptococci were present in the pleural exudate also ceases. (Charts VIII and IX.)

TABLE 8.[a]—*Epidemiological table for Camp Meade, Md.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	0	0	0	0	0	0.24	7.44	0	0	0	0
November	0	0	0	0	0	.93	14.17	0	0	0	0
December	1	0	1	0	1	1.61	12.07	0.0269	0.0269	0	0
1918.											
January	11	5	5	3	0	2.87	49.33	.3667	.1667	0.1000	45
February	10	6	6	0	0	1.28	22.94	.3167	.1900	.0	60
March	16	7	13	1	0	2.75	47.94	.4931	.4007	.0308	44
April	6	2	2	3	0	2.02	27.80	.2233	.0744	.1116	33
May	4	0	0	0	0	.78	15.13	.1222	.0	.0	0
June	0	0	0	0	0	.26	5.72	0	.0	.0	0
July	0	0	0	0	0	.29	5.34	0	.0	.0	0
August	0	0	0	0	0	.42	8.77	0	.0	.0	0
September	11	1	6	3	0	2.66	231.74	.3093	.1688	.0844	9
October	22	4	9	5	0	9.79	140.69	.4592	.1878	.1669	18
November	2	0	1	1	0	.54	21.12	.0465	.0232	.0232	0
December	4	2	2	1	0	.64	24.53	.1082	.0541	.0271	50
	87	27	45	17	1	....	....	....	....	....	31

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP LEE.

Camp Lee, Va., was situated about 3 miles from Petersburg, on a plateau of sandy loam, muddy in wet weather, dusty in dry. It was a National Army cantonment, composed, in 1917, of drafted men from Virginia, West Virginia, and Pennsylvania.[10] It contained over 12,000 enlisted men in September of that year and the number rapidly increased, the average strength in November exceeding 35,000.[10] After the departure of the 80th Division, about May, 1918, Camp Lee was used as a replacement camp, but its strength was maintained at a high level throughout 1918. Nearly two-thirds of the men reaching camp in 1917 came from rural districts. On an average, approximately 13 per cent of the enlisted men were colored.[10]

There were 1,575 cases of measles during the 15 months from October, 1917, to December, 1918.[11] These measles cases presented two periods of high incidence. The first embraced November and December, 1917, and January, 1918, the cases for these months aggregating 549; the other extended through June, July, and August, 1918, and totaled 438. The cases of empyema, recorded as following measles, were 23 in number, constituting 1.4 per cent of the measles, and a little less than 15.5 per cent of the total for empyema (149). The chronological distribution of these diseases shows little relation between the two. In the first period the high incidence of empyema continued two months after that for measles had fallen off, while in the second period, also of three months' duration, only two cases of empyema appeared, while the total incidence of measles was, as stated, 438 cases. In the first period, the percentage for empyema was 17 of the total for measles, in the later period it was less than one-half of 1. Of the 23 cases of postmeasles empyema, so designated in the special empyema records, 3 died, a mortality of 13 per cent, whereas the mortality for all the empyemata, based on the same data, was 16.1 per cent. This low mortality in the postmeasles cases of empyema does not correspond with the experience in other camps.

Usually these cases fared less well than those with other histories. It is not possible to determine the reason for this apparent exception at Camp Lee, but reference may be made, in this connection, to the fact that fatal cases generally reveal adequate explanation of death irrespective of the empyema. It is a question whether empyema alone was responsible for many fatalities. In most cases it may be viewed as merely complicating pathological conditions of greater gravity. It might appear reasonable to class cases of death with empyema as due to the conditions with which it was associated, such as an extensive bilateral pneumonia, pericarditis, peritonitis, or meningitis following otitis media. Were this view consistently held, the number of deaths attributed to empyema would be materially affected, and some cases might be overlooked in examining the records. It is not feasible to determine whether these considerations apply to the records at Camp Lee. It appears quite certain, however, from the data already given, that no evidence is available in support of a close relation between measles and empyema, although the impression that such was the case prevailed during the first period of high incidence.[11]

Eleven cases of empyema are noted as following rubella.[12] One of these also had measles and is included among the fatal postmeasles cases already cited. The disease occurred in December, 1917, and as this death was the

only one at Camp Lee following rubella, it can not be associated with that disease except by coincidence. The other 10 cases were prior to the spring of 1918, and nearly all before the middle of January. Since about 400 cases of rubella had appeared in camp by that time, and there were subsequently over 2,000 cases, no epidemiological importance can be attached to a relationship between the two diseases.

There were but few (26) cases of scarlet fever, and none was followed by empyema.[11]

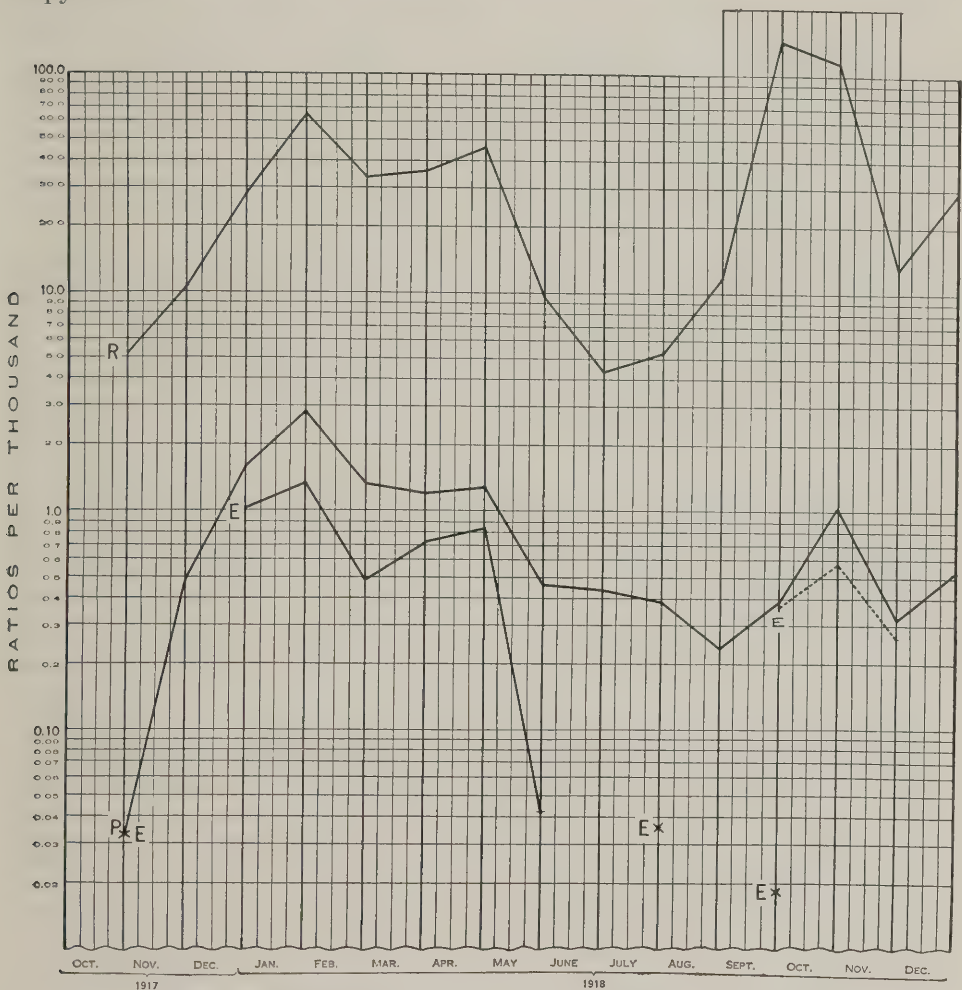


CHART X.—Epidemiological chart for Camp Lee, Va., in monthly ratios per thousand men.

The relation between streptococcus infection and empyema is particularly striking in the special empyema records from Camp Lee. Of the 149 cases, bacteriological examinations were reported in 114 (76.5 per cent).[12] Of these, 109 (95.6 per cent) show the presence of streptococcus in the pleural fluid, usually the hemolytic variety, and 5 (4.4 per cent) show the presence of pneumococcus. Four of the cases in which the exudate contained pneumococcus alone were in January, 1918, when the incidence of empyema was greatest (43 cases). They all appear to have followed primary lobar pneumonia and resulted in

recovery with but slight disability. The fifth was in July, following lobar pneumonia. This case was operated and returned to duty 72 days after admission, the history having been uneventful. The other case, occurring at about the same time, was also a lobar pneumonia and recovered without operation. There was no record of a bacteriological examination.

These last two cases are particularly referred to because they fall into a period of low incidence of respiratory diseases at Camp Lee. They appear to have been sporadic cases of no considerable epidemiological importance.

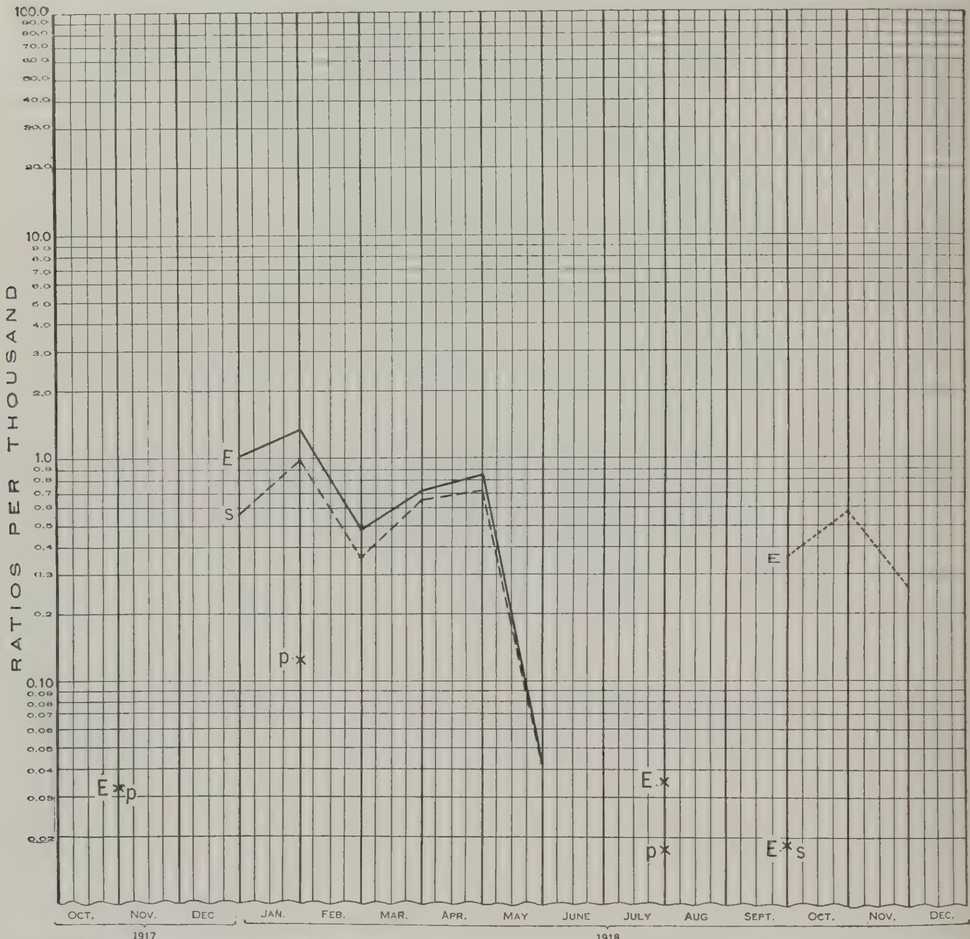


CHART XI.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Lee, Va.

When compared with those of the preceding camps, the graphic chart for Camp Lee is remarkable for the low position of the curve for pneumonia. It is very close to that of empyema and relatively distant from that representing diseases of the upper respiratory tract, nor does it so closely follow the direction of the latter as was the case at Camp Meade. Apparently the pneumonias were relatively less abundant, but more frequently complicated with empyema. This close relationship between the pneumonias and empyemata was presumably due to the prevalence of hemolytic streptococci at that time. The path-

ology of pneumonias associated with this organism shows that they are prone to develop empyema. (Vide Chapter III.)

The special empyema records contain but a single case of empyema during the pandemic of influenza in the autumn of 1918.[12] But in a "Diary of the Base Hospital, Camp Lee, Va.," [17] by the commanding officer, it is stated that cases of influenza appeared on September 13, and that 8 days later bronchopneumonia made its appearance, being followed, up to December 1, by 60 cases of empyema, with only 2 deaths due to complications. Thirty-seven of the cases came to operation. Neither the distribution in time nor the bacteriology of these cases is given. They can not, therefore, be accurately included in the tabulation of cases for this camp. In Charts X and XI they are represented by a dotted line indicating the probable distribution. The total number of empyema cases is small; for there were 7,773 cases of influenza during this period (September 13 to December 1, 1918) and the mortality was low. This may be attributed to the successful efforts to avoid crowding the patients, barracks being evacuated for their reception, and additional medical officers and nurses being provided for their care. All these provisions were made in advance of the requirements, so that no overwhelming emergency occurred at any time. It is believed that the low incidence of pneumonias, as well as empyemata, was due to this foresight and energy.

TABLE 9.[a]—*Epidemiological table for Camp Lee, Va.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	1	0	0	0	0	0.03	5.17	0.0324	0.0	0.0324	0
November	0	0	0	0	0	.48	10.57	.0	.0	.0	0
December	34	8	19	0	0	1.58	28.16	1.0235	.5722	.0	24
1918.											
January	43	1	32	4	0	2.84	64.05	1.3190	.9820	.1228	2
February	16	0	12	0	0	1.31	32.88	.4779	.3540	.0	0
March	23	6	20	0	0	1.17	35.50	.7256	.6532	.0	26
April	27	8	23	0	0	1.28	45.58	.8411	.7180	.0	30
May	2	1	2	0	0	.46	9.74	.0419	.0419	.0	50
June	0	0	0	0	0	.43	4.28	.0	.0	.0	0
July	2	0	0	1	0	.38	5.28	.0349	.0	.0175	0
August	0	0	0	0	0	.23	11.72	.0	.0	.0	0
September	1	0	1	0	0	.38	142.78	.0183	.0183	.0	0
October	0	0	0	0	0	1.06	114.16	.0	.0	.0	0
November	0	0	0	0	0	.32	12.95	.0	.0	.0	0
December	0	0	0	0	0	.53	28.71	.0	.0	.0	0
	149	24	109	5	0						16.1

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP GREENE.

Camp Greene, near Charlotte, N. C., was a tent camp used to organize the 4th and 5th Regular Divisions. There were several thousand troops there during the latter part of 1917, but the strength increased very considerably during the first few months of 1918.[10] The weather proved wet and cold, and the men were much exposed both outside and in the tents, fuel and clothing being insufficient for this particular season. The ensuing close crowding probably influenced the spread of infections among the men.[10]

Information concerning empyema at Camp Greene is not confined to the special empyema records, which are mainly concerned with cases reaching the surgical service of the base hospital. The reply, dated March 5, to the questionnaire of February 21 gives an account of 26 cases prior to March 1, not included in the special records.[9] Of these 26 cases, 25 were not operated. The discrepancy between the two is therefore reduced to a single operated case. A published article by Elwyn, the internist on the local empyema team, includes a discussion of complicating empyema based upon the data given in the reply to the questionnaire.[18]

There were many cases of measles at Camp Greene during the last three months of 1917 and the first three months of 1918, aggregating 1,435 for the six months.[11] During this period there were 73 cases of empyema upon which operations were performed and the 25 additional unoperated cases just referred to, making a total of 98, or 6.8 per cent of the measles. But the records specify only 43 cases of postmeasles empyema. This figure would reduce the ratio to 3 per cent. But even this is a higher proportion than those in the camps hitherto studied. The mortality was also higher (28 cases), reaching 65 per cent. The explanation of these high ratios is furnished by the bacteriology. In the reply to the questionnaire, it is stated that the organisms found in the order of their frequency were streptococcus hemolyticus, streptococcus viridans, and pneumococcus—never alone. The special empyema records, out of a total of 32 examinations, report 31 (97 per cent) as yielding a streptococcus, and only 1 associated with the pneumococcus.

Extending the period under consideration to include the whole of 1918, out of a total of 125 empyema cases, there are bacteriological records concerning 47 cases. In 42 of these (89 per cent) streptococci were found, in 5 (11 per cent) the pneumococcus.[12]

There were 4 cases of empyema following rubella, with 1 death. All of the 4 cases of empyema were associated with the streptococcus in pleural exudate. There were over 2,500 cases of rubella in the camp.[11]

In no case is there a record of scarlet fever preceding empyema.[12]

The reply to the questionnaire contains one very suggestive group of cases: "(d) Empyema without measles or pneumonia: Total cases 14; deaths, 4; mortality, 28.5 per cent; operated cases, 11; deaths, 1; mortality 9.1 per cent." No further details are given in the reply to the questionnaire; but in Elwyn's article there are several references to such cases.[18]

In this article Elwyn states that, in addition to the empyemata complicating lobar pneumonia, there were many empyemata complicating the purulent bronchitis following measles, and some empyemata secondary to other infections. From the beginning of the epidemic to March 1, 1918, there were 14 cases of empyema following bronchopneumonia or lobar pneumonia complicating measles, with 10 deaths (71.4 per cent mortality); 29 cases of empyema complicating measles alone, with 18 deaths (62 per cent mortality); and 14 cases of empyema unassociated with either measles or pneumonia with 4 deaths (28.5 per cent mortality).

Among the 393 cases of primary lobar pneumonia there were 45 cases of empyema (11.4 per cent) with 21 deaths (46.6 per cent mortality).

A class of empyemata is described that presented a picture totally unlike any other cases of empyema the writer (Elwyn) had seen.[18] These were very

severe cases and frequently appeared after the pneumonia had subsided; they appeared also in the course of measles, bronchitis, and, in a few cases, secondary to tonsillitis, or without any assignable cause. The course of events was as follows: "The patient was admitted for measles, and developed during the course the ordinary mild bronchitis accompanying measles. This gradually increased in severity, and after a time became purulent, involving every bronchus and bronchiole in both lungs. This was followed by consolidation of one or

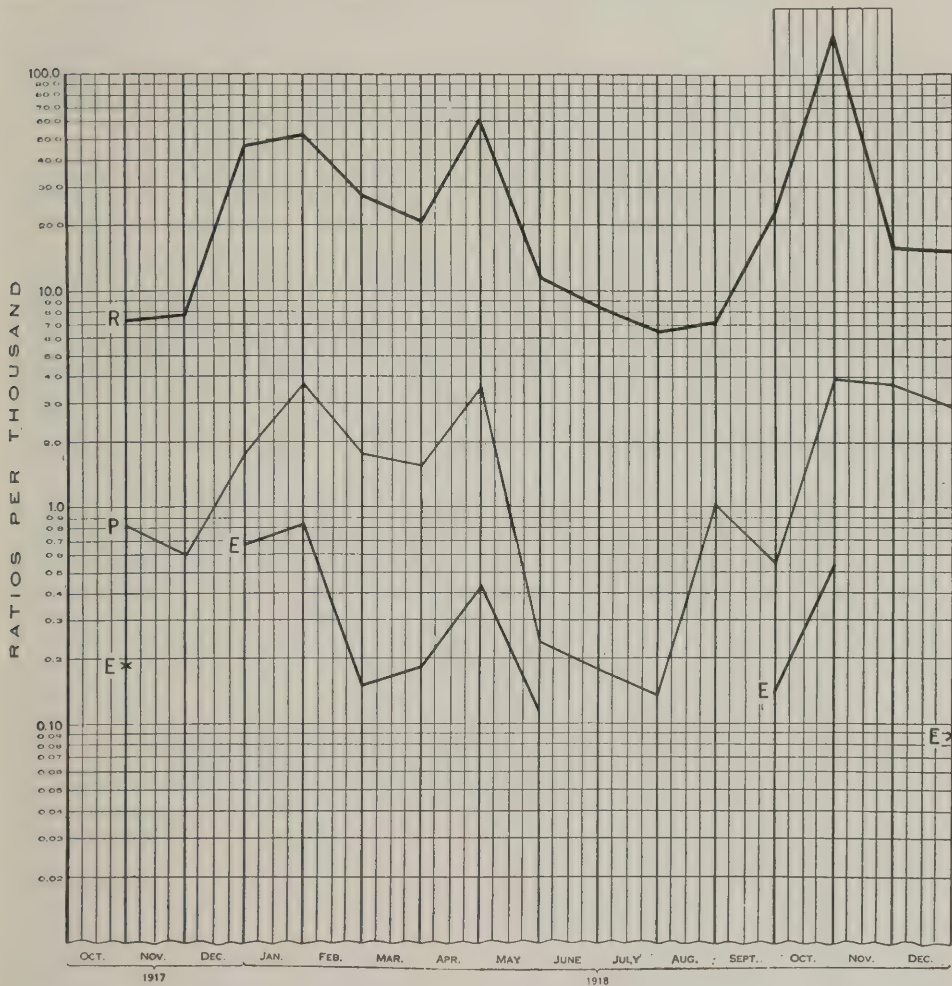


CHART XII.—Epidemiological chart for Camp Greene, N. C., in monthly ratios per thousand men.

more lobes. Empyema complicated the pneumonia or occurred without the pneumonia." [18]

A more extended discussion of such cases must be deferred to the chapter on pathology; but that streptococcic infections may penetrate the pleura without clearly defined clinical evidence of pulmonary consolidation has much epidemiological significance. It suggests that empyema is not always and necessarily a sequela of pneumonia, but that the incidence of the two may to some extent be dissociated.

For the later, or influenzal, period of high incidence, data additional to those in the special empyema records are furnished by an article in the current medical literature.[19] The period covered is from September 1, 1918, to February 28, 1919, but doubtless most of the cases included were in October, 1918. Of the 39 cases with pleuritic effusion, positive bacteriological data are given in 16. Of these, 56 per cent (9 cases) fall into the streptococcus group and 44 per cent (7 cases) into the group of pneumococcus infections. This proportion is of the same order as that furnished by the special empyema records for the

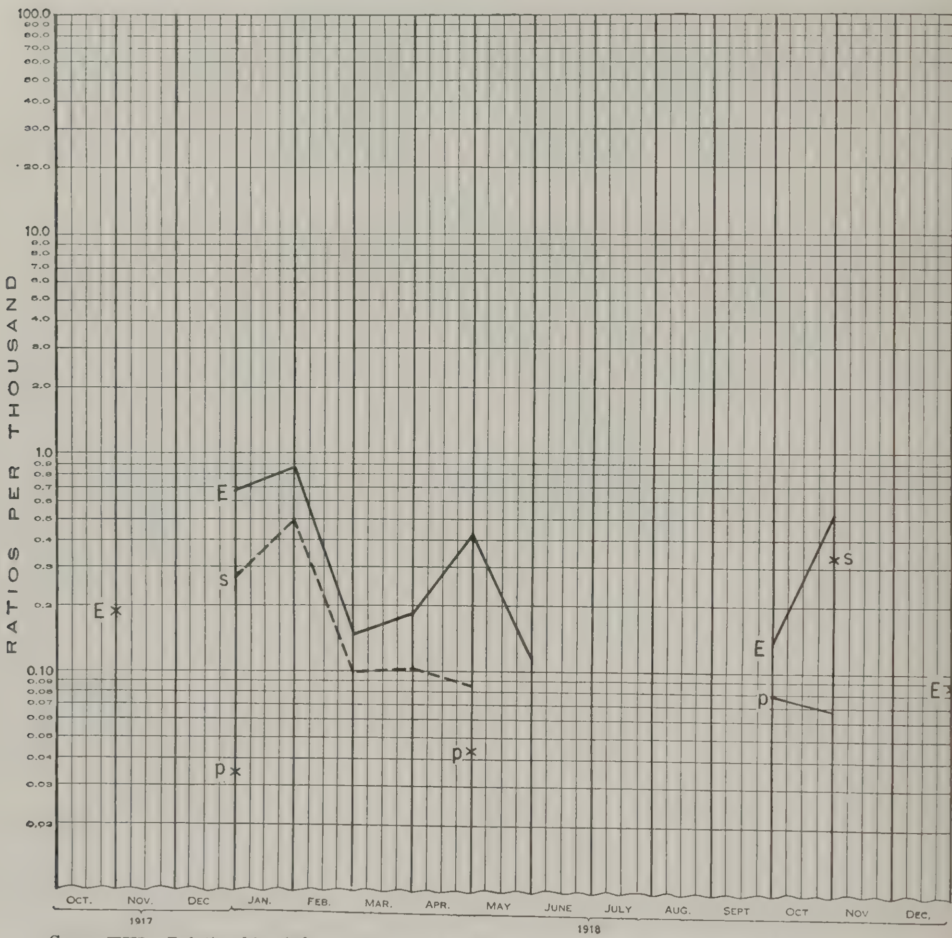


CHART XIII.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Greene, N. C.

shorter period ending with December, 1918. Although the number of cases is smaller, streptococci constituted 62.5 per cent, pneumococcus 37.5 per cent.

A mere glance at the curves given in Chart XII suffices to reveal the opposed trend of the pneumonias and empyemata, and the general correspondence of the latter to diseases of the upper respiratory tract. In this camp the empyema curve is interrupted between June and October, there being no case for July, August, and September. During those three months, the incidence of upper respiratory diseases was less than 1 per cent of the command. This

relationship between affections of the upper respiratory tract and empyema was called to the attention of the medical officers at the time, as is evidenced by the information abstracted from the article by Elwyn.[18] The clinical detection of inconspicuous pneumonic processes in the presence of empyema is clearly shown to be difficult.

TABLE 10.[a]—*Epidemiological table for Camp Greene, N. C.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	3	0	0	0	0	0.82	7.29	0.1863	0.0	0.0	0
November	0	0	0	0	0	.60	7.83	.0	.0	.0	0
December	20	6	8	1	0	1.78	46.96	.6734	.2689	.0336	30
1918.											
January	33	16	19	0	0	3.65	52.85	.8518	.4908	.0	48
February	6	3	4	0	0	1.74	27.80	.1499	.0991	.0	50
March	7	3	4	0	0	1.59	20.72	.1808	.1029	.0	43
April	10	4	2	1	0	3.57	60.99	.4292	.0860	.0429	40
May	2	0	0	0	0	.24	11.44	.1130	.0	.0	0
June	0	0	0	0	0	.18	8.41	.0	.0	.0	0
July	0	0	0	0	0	.13	6.46	.0	.0	.0	0
August	0	0	0	0	0	1.06	7.16	.0	.0	.0	0
September	2	0	0	1	0	.54	22.94	.1386	.0	.0793	0
October	15	2	5	1	0	3.91	149.67	.5386	.3315	.0663	13
November	0	0	0	0	0	3.63	15.99	.0	.0	.0	0
December	1	0	0	1	0	2.91	15.39	.0873	.0	.0873	0
	99	28	42	5	0						28.3

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP HANCOCK.

Camp Hancock, Ga., located near the city of Augusta, was used for men of the National Guard from Pennsylvania, reinforced later from New York and to a relatively slight extent from other States.[10] The 28th Division, organized here, was moved overseas about May, 1918, after which the camp was used as a machine-gun replacement camp.[10] The men were quartered in tents. The weather during the winter of 1917-18 was unusually cold for this part of the country, but not wet, and there is no indication that the men suffered hardship from exposure.

The strength of the camp was high from the beginning, 27,000 men were received in September, 1917, and the number in camp ranged between this figure and 34,000 until May, 1918, when it fell to somewhat under 12,000 on the departure of the 28th Division.[10]

The special empyema records from this camp are deficient in the number of cases given for the early months. They detail only 6 cases prior to March, 1918,[12] whereas the reply to the questionnaire of February 21 records 18 for this period;[8] but the actual dates for these 18 are not given, so that it is not possible to place them in chronological order. The cases which occurred during the 1918 autumnal period of high incidence are probably more correctly reported in the special empyema records.

Cases of measles were not numerous at Camp Hancock. For the whole period of 15 months to and including December, 1918, there were 640, but 434 of these were during the last 4 months.[11] Prior to March 1, 1918, 96 cases were admitted to the base hospital. Four of these developed pneumonia, but none an empyema which could be demonstrated clinically, though in one case a small pocket of pus was found at autopsy on the under surface of the right lower lobe and not at the periphery of the lung. Counting this case, less than 1 per cent of the measles during this period developed empyema.[11]

In the following November there was another postmeasles case, following bronchopneumonia. This was associated with pneumococcus, Type IV, and recovered. During this month there were 238 cases of measles, 45 complicated with pneumonia, almost exclusively lobular.[11]

There were nearly a thousand cases of mumps at Camp Hancock during the 15 months, but none of these developed empyema.[11]

Empyema followed scarlet fever in two cases.[11] In the pleural fluid of one, pneumococcus, Type IV, was found; in the other, a diplococcus, the species not defined. Both cases originated in November, within two days of each other, and both recovered. The total number of cases of scarlet fever for 1918 was 388, but the chronological distribution of these can not be given.

In the reply cited above the following data concerning the organisms found in pleural fluids are given: Pneumococcus alone (9); streptococcus alone (3); streptococcus and pneumococcus together (2); undetermined (4). Taking into account only the positive findings and giving precedence to the streptococcus, this would be associated with 36 per cent of the cases. According to the special empyema reports, the ratio was 38 per cent for the whole 15 months. The streptococcus apparently played a much less important part at Camp Hancock than in the camps hitherto considered in this chapter. It is possible, however, that this would be an erroneous conclusion were it applied to all periods. In October, 1918, there was a marked rise in the number of empyema cases. Taking the total for the whole 15 months at the known figure, 60 (probably too low), 25 (40 per cent) fall in the month of October, 1918, with a mortality of 24 per cent (six cases). The bacteriology for the 19 surviving cases is given as pneumococcus, Type IV, 16; Type IV with hemolytic streptococcus, 1; Type I, 1; "diplococcus," 1. The bacteriology for the six fatal cases is given as Type IV, 3; Type III, with hemolytic streptococcus, 1; hemolytic streptococcus alone, 1; "streptococcus," 1. It is striking that, out of the 25 cases, 19 should be associated with pneumococcus, Type IV, and that streptococci should have played a rôle so minor, for: "Prior to the epidemic of influenza at Camp Hancock there occurred in one company an outbreak of hemolytic streptococcus infection of peculiar virulence and uniform course. There is reason for thinking that the spread of disease in these cases was by food or milk infection." [20] There were but few cases of empyema at that time. Autopsy showed a streptococcus infection, with a remarkable affinity for the trachea, gradually extending down through the bronchi; and, though there was a visible peribronchitis and peritracheitis, the larynx and the lungs escaped invasion. This series of cases is mentioned because there were points of similarity with the bronchitis which accompanied influenza infection later and which uniformly showed a bronchitis and peribronchitis very similar to these cases, but accompanied by pulmonary emphysema and what was called bronchopneumonia.

In October, 1918, the influenza epidemic reached its height at this camp, and in the article just quoted[20] appears a description of cases of interstitial pneumonia like those described at other camps, with localized and often multiple empyemata and pulmonary abscesses. It appears probable that streptococcus was associated with many of these cases. The bacteriological findings are given as varied, but no statistics are presented. The involvement of the pleura is described as tardy and was attributed, at least in some cases, to rupture of lung abscesses into the pleural cavity after adhesions had formed. In conse-

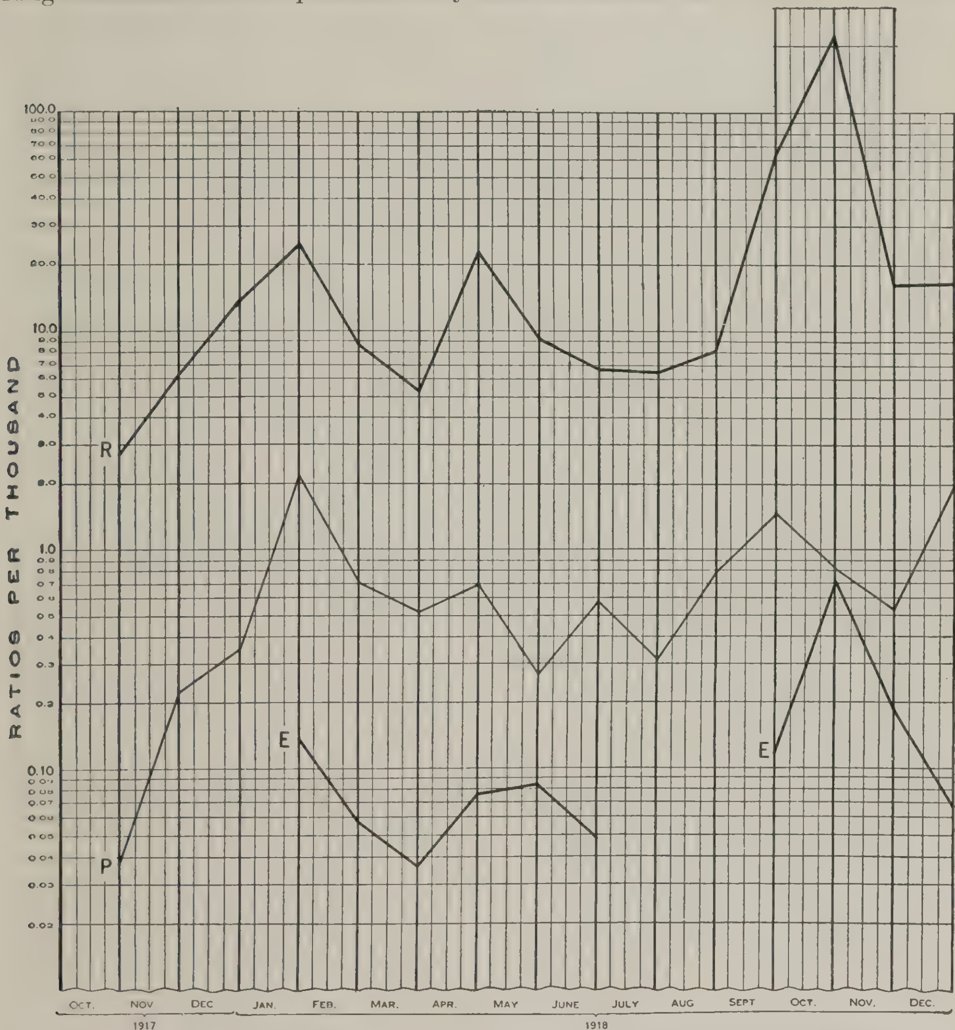


CHART XIV.—Epidemiological chart for Camp Hancock, Ga., in monthly ratios per thousand men.

quence, the empyemata were localized and in some cases drained spontaneously through a bronchial communication. Cases of this character are of great interest; they suggest a slowing down of a process which at other camps proceeded with great rapidity. There were 6,813 cases of influenza at Camp Hancock in October, 1918, with 274 deaths, a mortality of 4 per cent.

Chart XIV, based, as to empyema, on the special empyema records, but in all other respects upon the sick and wounded records in the office of the Sur-

geon General of the Army, is of interest because of the low incidence of common respiratory affections (R) until the advent of epidemic influenza. In February and March, the incidence of these diseases fell below 1 per cent of the command, and was but a little over 0.5 per cent in the latter month. After the relatively high incidence in April, the number again fell off and did not rise above 1 per cent until the following September.

If the observations made in the preceding camps on the relations between empyema and common respiratory diseases were applicable to Hancock, one

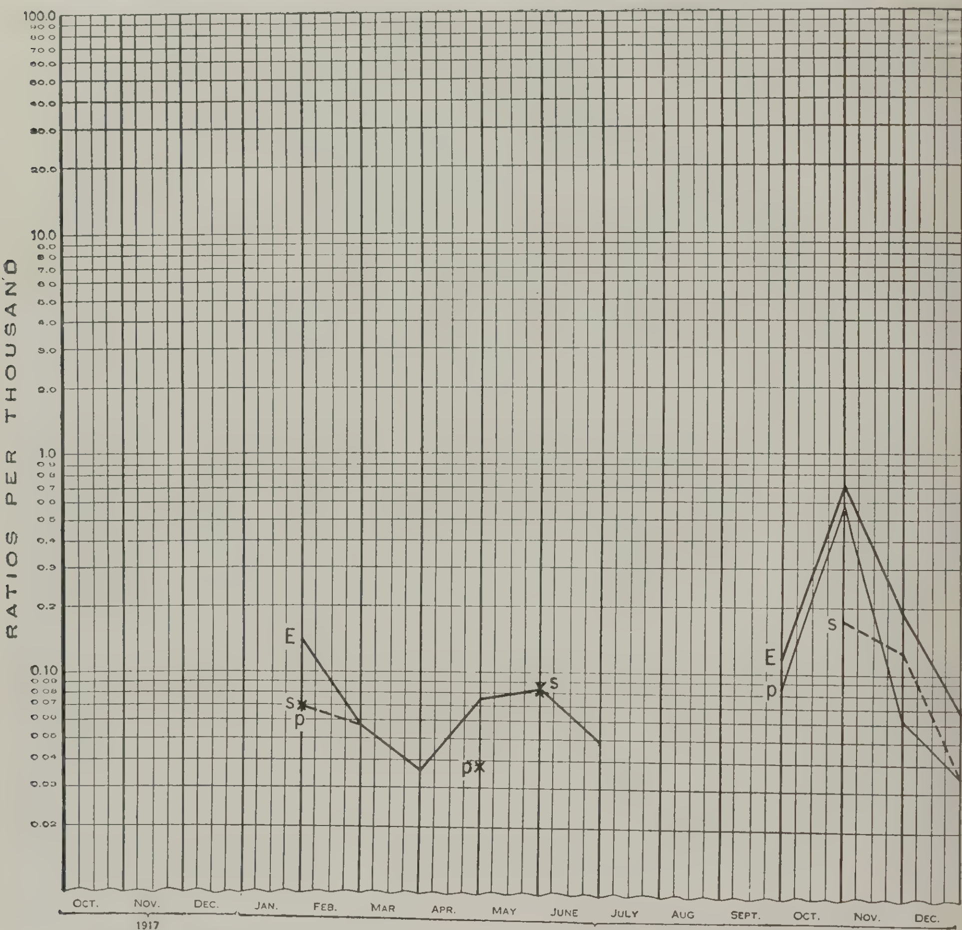


CHART XV.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Hancock, Ga.

might expect an absence of empyema in March, May, and June. According to the records,[12] there actually was but one case in each of these months, and the histories of these are not without some significance. The case occurring in March developed a pneumonia in the right lower lobe after an operation (appendectomy) presumably performed under general anesthesia. Empyema was discovered 10 days later when 20 c. c. of pus were aspirated from the chest. A portion of the eighth rib was removed the following day. Later, a substernal abscess was drained; and about four months after admission to the hospital, the case was transferred to Fort McPherson, Ga. There does not appear to have been fur-

ther operative treatment, and the patient was discharged from the Army on January 25, 1919. There is no bacteriological record of this case. The case in May also followed anesthesia. Bronchopneumonia of the left lower lobe was diagnosticated on May 9, and empyema on the right side three days later. Resection of the eighth rib was done on May 18, and the wound closed about three months later. Influenza bacilli and nonhemolytic streptoccoci were obtained from the purulent exudate. The case made a good recovery. The last of this group of cases was admitted for lobar pneumonia on June 3, developed empyema 12 days thereafter, and four days later was operated, a portion of the ninth rib being resected, and about 100 c. c. of pus evacuated. A good recovery followed, but the patient suffered from shortness of breath and was discharged from the Army on December 17. There are no bacteriological data.[12]

The foregoing histories definitely connect two of these cases with a preceding anesthesia which probably had an influence in determining the empyema. The third case appears to have been a sporadic case of pneumococcus pleural infection, such as might occur at any time of year appear in a population of over 20,000 people. None of the cases necessarily invalidates the impression that empyema cases drop to insignificant figures when infections of the upper respiratory tract fall below 1 per cent.

TABLE 11.[a]—*Epidemiological table for Camp Hancock, Ga.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	0	0	0	0	0	0.04	2.74	0	0	0	0
November	0	0	0	0	0	.22	6.32	0	0	0	0
December	0	0	0	0	0	.35	13.94	0	0	0	0
1918.											
January	4	1	2	2	0	2.18	24.44	0.1380	0.0690	0.0690	25
February	2	2	2	0	0	.71	8.69	.0571	.0571	.0	100
March	1	0	0	0	0	.52	5.30	.0357	.0	.0	0
April	2	0	0	1	0	.69	22.82	.0745	.0	.0373	0
May	1	0	1	0	0	.26	9.26	.0846	.0846	.0	0
June	1	0	0	1	0	.58	6.62	.0487	.0	.0	0
July	0	0	0	0	0	.31	6.44	.0	.0	.0	0
August	0	0	0	0	0	.78	8.03	.0	.0	.0	0
September	4	0	0	3	0	1.45	63.91	.1177	.0	.0859	0
October	25	6	6	19	0	.82	220.63	.7112	.1710	.5700	24
November	6	0	4	2	0	.53	16.15	.1841	.1232	.0615	0
December	2	0	1	1	0	1.99	16.59	.0682	.0341	.0341	0
	48	9	16	27	0	....	....	....	....	....	18.8

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP SEVIER.

Camp Sevier, S. C., was about 4 miles from Greenville, a city with about 20,000 inhabitants.[10]

Troops of the National Guard from Tennessee, North Carolina, and South Carolina were assembled here, but were soon augmented by drafted men transferred from other camps.[10] Early in November, 1917, the strength reached 27,000 and remained at about that figure until May, 1918, when the 30th Division was sent overseas. The number of men in camp did not again reach 20,000 until the following September. There were no colored men prior to September, 1918. The troops were quartered in tents.[10]

The incidence of measles in this camp was high.[11] For the months of 1917 the total admissions for this disease were 3,005. For 1918 they were 665. The largest number for any single month was 2,524 in November, 1917, after which there was an abrupt falling off to 150 in December, and in March, 1918, only seven cases were admitted. There were four cases of postmeasles empyema included in the special empyema records.[12] One of these was admitted November 23, and the three others between December 3 and 7, 1917. The first case ended in death six days after the onset of empyema; an autopsy re-

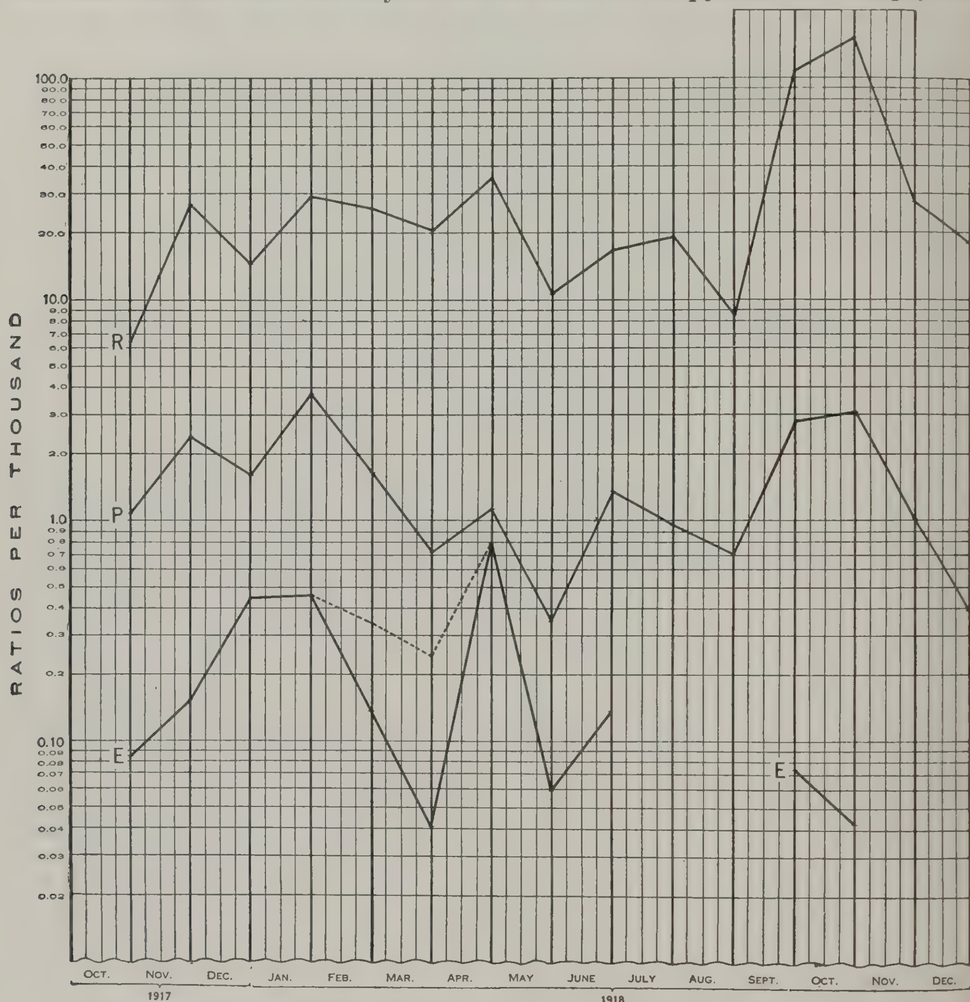


CHART XVI.—Epidemiological chart for Camp Sevier, S. C., in monthly ratios per thousand men.

vealed general bronchopneumonia with pulmonary abscesses, bilateral empyema and mediastinal abscesses; and smears of the pus contained pneumococcus and streptococcus. In the three surviving cases a bacteriological examination is recorded for one only, a pneumococcus being found. Even though a small number of empyema cases probably escaped inclusion in these records, it is obvious that measles had little to do with the incidence of empyema.

The same is true of mumps. Only one case of empyema appears to have followed this infection; a fatal case, admitted for mumps December 31, 1917,

a month when there were 306 admissions for this disease, while in January, February, and March, 1918, there were over 3,900 such admissions with no cases of empyema developing among them. There was no postscarlatinal empyema.[12]

Table 12 is based upon the special empyema reports, to preserve uniformity in this respect with the other camps represented on the map shown in Figure 3 (p. 49). But as already set forth, these data must be regarded as minimal rather than absolute. Thus, for Camp Sevier, in the reply to the question-

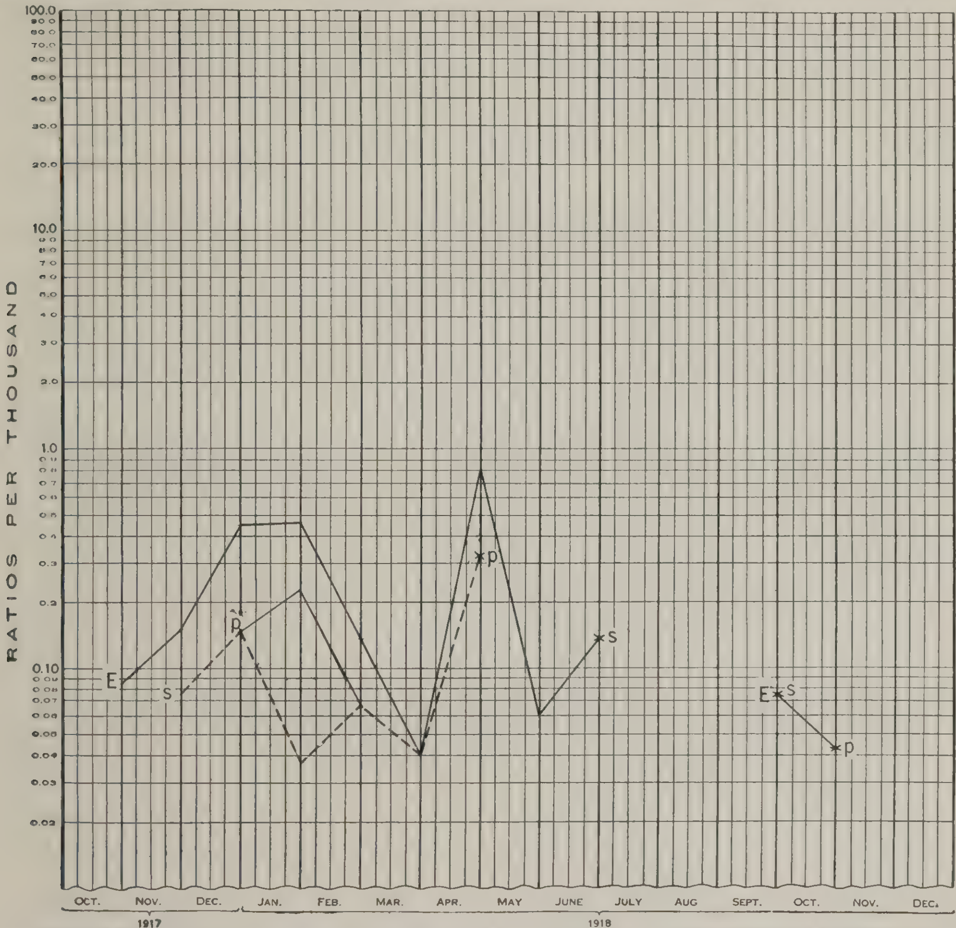


CHART XVII.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Sevier, S. C.

naire of February 21, 1918,[9] dated March 18, it is stated that there had been 46 cases of operated empyema, up to that time, 27 following lobar pneumonia and 19 following bronchopneumonia. This is 11 more than those contained in the special empyema reports. In the reply, there is no mention of any organism except pneumococcus. Of 42 positive findings, 39 were Type IV, two Type I, and one Type II. It appears justifiable to conclude that, at Camp Sevier, the streptococcus of whatever strain was less significant than in many other localities, and that, like Camp Hancock, pneumococcus, Type IV, predominated.

In Chart XVI the graphic transcription of the table brings to the eye very clearly the anomalous returns for February and March. According to the trend of curves at other camps, there should have been more empyemata in these months at Camp Sevier than were included in the special empyema records. As a matter of fact, as stated in the preceding paragraph, such was the case. There were 11 additional empyema cases that belong to the period prior to April 1, but among which months they should be distributed is unknown. If, purely as a matter of speculation, these 11 cases are divided as evenly as possible between February and March, six cases in the former and five in the latter month, the empyema curve would be modified as shown by the dotted line, giving to it a general resemblance to the curve "R."

The high incidence in April was coincident with a considerable increase of cases of influenza, which reached 653 in that month, in contrast to 143 the month preceding and 47 the month following. The organisms associated with the empyemata in April were about equally divided between the streptococcus and pneumococcus groups. Such has been the case in postinfluenzal empyema elsewhere.

The unusual rise of the curve "R" in June and July was not due to influenza, but to an increase in the "other respiratory diseases," and, corresponding to this, is a sympathetic rise in the empyema curve, coupled with an increase in the importance of the streptococcus. It would be straining the evidence to lay stress on particular deductions from such a small number of cases, but when such small groups of cases show the same correlation between empyema and infections of the upper respiratory tract as is displayed by much larger numbers in other and widely separated localities, this circumstance is not without significance.

TABLE 12[a].—*Epidemiological table for Camp Sevier, S. C.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group	Pneumococcus group.	
1917.											
October	2	1	0	0	0	1.05	6.28	0.0849	0	0	50
November	4	1	2	0	0	2.35	26.88	.1519	0.0760	0	25
December	12	4	4	4	0	1.59	14.42	.4396	.1465	0.1465	33
1918.											
January	12	5	1	6	0	3.70	29.17	.4493	.0374	.2246	42
February	4	0	2	2	0	1.62	25.46	.1343	.0671	.0671	0
March	1	1	1	0	0	.72	20.37	.0405	.0405	.0	100
April	10	4	4	4	0	1.12	34.43	.7911	.3166	.3166	40
May	1	0	0	0	0	.34	10.59	.0596	.0	.0	0
June	1	0	1	0	0	1.32	16.75	.1353	.1353	.0	0
July	0	0	0	0	0	.95	19.05	.0	.0	.0	0
August	0	0	0	0	0	.71	8.46	.0	.0	.0	0
September	2	1	2	0	0	2.81	108.56	.0741	.0741	.0	50
October	1	1	0	1	0	3.08	149.78	.0420	.0	.0420	100
November	0	0	0	0	0	1.01	27.51	.0	.0	.0	0
December	0	0	0	0	0	.39	17.93	.0	.0	.0	0
	50	18	17	17	0	....	....	....	....	....	36

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP WHEELER.

Camp Wheeler, Ga., was situated about 5 miles from Macon, a city of 40,000 inhabitants. The first contingent to arrive was composed of men of the National Guard from Alabama, Florida, and Georgia, supplemented by transfers from other camps.[10] The troops were quartered in tents. The winter was unusually cold, and the consequent exposure of the men was aggravated by a severe storm of snow and sleet about the middle of December, the effects of which were said to last 10 days. In dry weather the camp was very dusty.

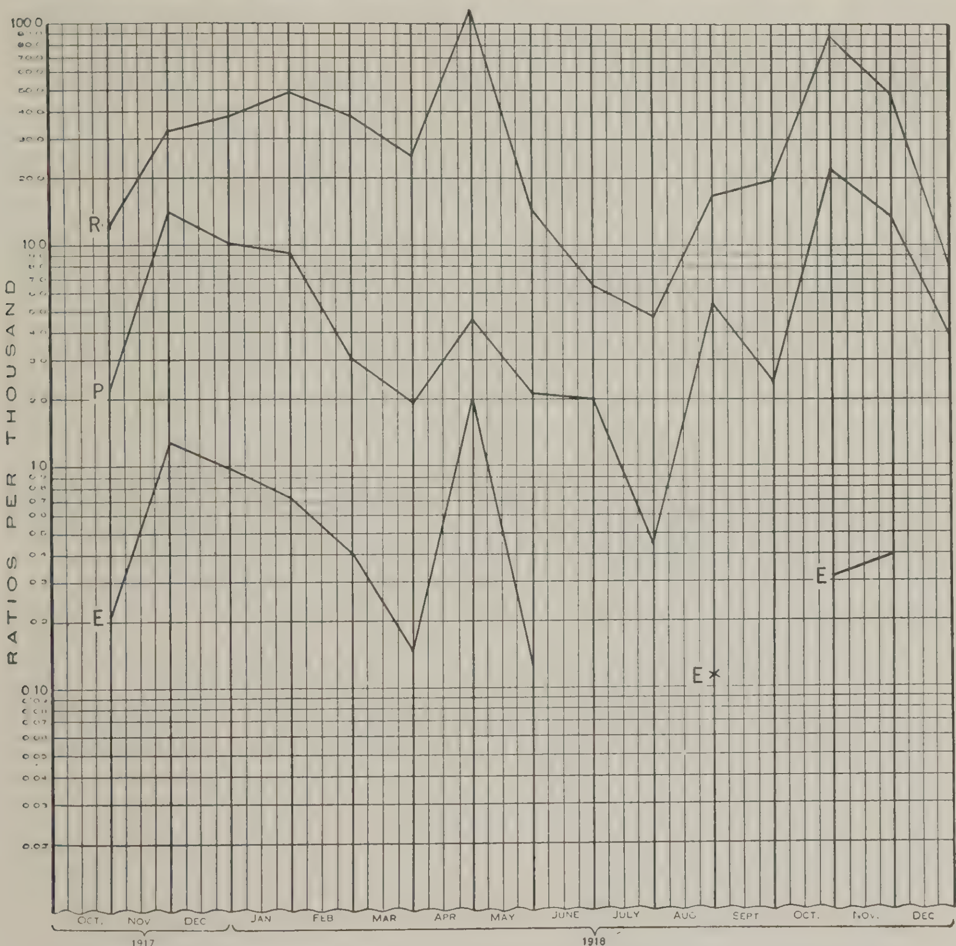


Chart XVIII.—Epidemiological chart for Camp Wheeler, Ga., in monthly ratios per thousand men.

These conditions may account, at least in part, for the relatively high incidence of respiratory diseases.[10]

As the base hospital was not fully established until the beginning of 1918, there were no special empyema records from this camp. The sources of information concerning the occurrence of empyema at Camp Wheeler, and upon which this study is based, are the reply to the questionnaire of February 21, 1918,[9] the clinical histories transmitted to the Surgeon General's Office after the base hospital was closed,[21] and unpublished clinical notes furnished by the chief of the surgical service.[22] Lacking a full index of diseases, the records from the

hospital were not in shape for ready reference, and in view of this and of the many thousand pages of daily notes which it was necessary to study, it appears unavoidable that some cases of empyema have been overlooked. Furthermore, under the conditions of unpreparedness just indicated, facilities for bacteriological examinations must have been deficient, and it is not surprising that in many cases records are entirely lacking. Notwithstanding these difficulties in obtaining them, it is probable that the data actually used compare favorably with those obtained from other camps from which the special empyema records were received.

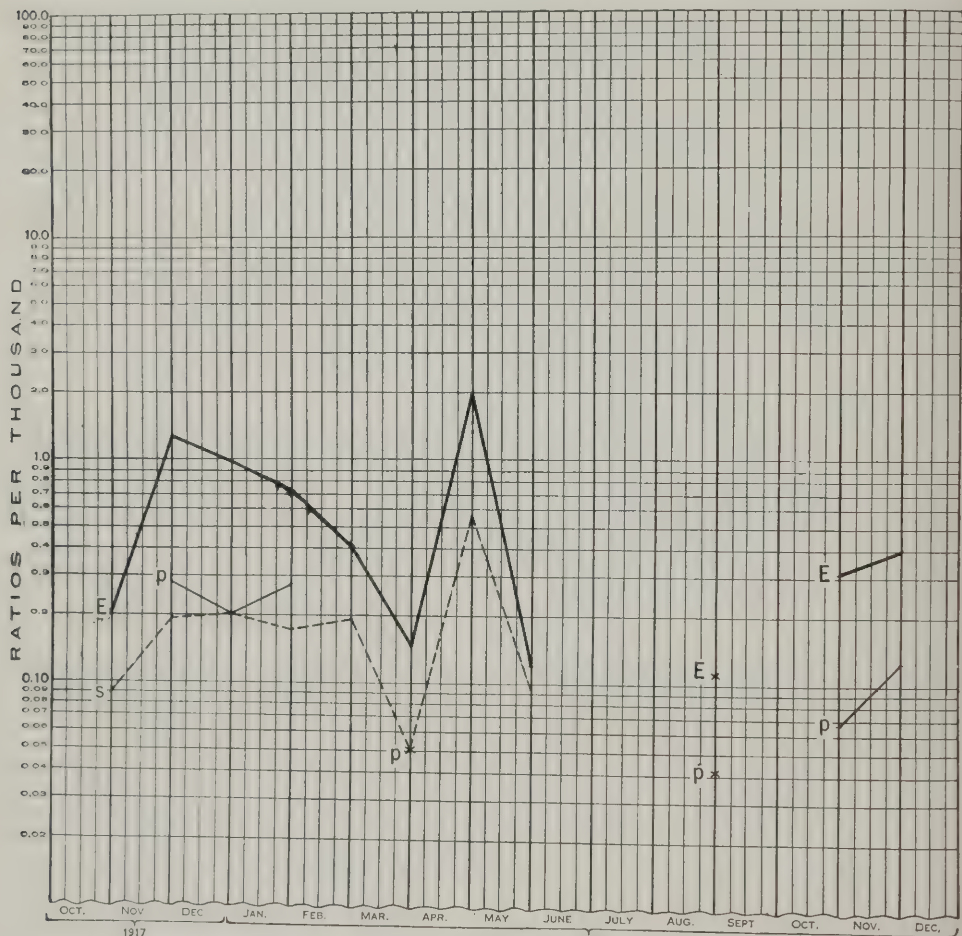


CHART XIX.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Wheeler, Ga.

There was a very high incidence of measles in the fall of 1917.[11] For November there were 2,421 cases, 86 of which were complicated with pneumonia, about equally divided between the lobar and lobular varieties. Ten of these 86 pneumonias developed empyema, with 6 deaths. This is a ratio of empyema to measles of about 0.41 per cent but a mortality of 60 per cent among the postmeasles empyemata, against 38.3 per cent for the total number of empyemata. During the remainder of the year there were three postmeasles

cases, with one death, although the admissions for measles had fallen to a relatively insignificant number.

Following mumps, five cases of empyema are on record, none fatal, although the admissions for mumps reached 5,379.[11]

There was no case of postscarlatinal empyema.[12]

It is important to note that in 20 cases during the autumn of 1917 and early in 1918 it is stated that the men suffered from severe colds (in one case with tonsillitis) prior to admission. This number would constitute about 22 per cent of the empyema cases recorded for that period.

The available bacteriological data indicate that 70 per cent of the cases examined belong to the streptococcus group and 30 per cent to the various types of pneumococcus.[12]

Chart XVIII for Camp Wheeler resembles Chart XVI for Camp Sevier. There is a similar abrupt but transient increase of empyema in April. This is here, also, coincident with an outbreak of influenza, which claimed 1,967 cases in that month against 245 in March and 167 in May. This outbreak occasioned a rise in the curve "R" higher than the autumnal peak in October. The course of the pneumonia curve in relation to the curve "R" suggests a possible difficulty in deciding how to classify some of the respiratory diseases at this camp, an uncertainty as to whether they should be placed among the influenza cases, regarded as bronchitis, or classed as pneumonia. In general, it may be observed that while all three curves rise or fall together, the excursions of the empyema curve are intermediate in extent between those of "P" and "R." If the grouping of the respiratory diseases were somewhat uncertain and not always completely consistent this might readily be reflected in the curves on the chart in just the way actually shown. It is not possible with the available data to analyze the conditions prevailing from month to month. Were it certain that the statistical data were complete, the chief interest would lie in a study of the pneumonias and other respiratory diseases rather than the empyemata.

TABLE 13.[a]—*Epidemiological table for Camp Wheeler, Ga.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group	Pneumococcus group.	
1917.											
October	5	2	2	0	0	2.41	13.95	0.2211	0.0885	0	40
November	35	13	3	2	0	15.34	33.99	1.3905	.1985	0.2780	37
December	24	11	6	2	0	10.68	38.21	.9673	.2015	.2015	46
1918.											
January	16	8	4	5	0	9.22	49.20	.7263	.1818	.2727	50
February	10	5	4	0	0	3.04	38.90	.3977	.1900	.0	50
March	3	1	1	1	0	1.96	26.44	.1507	.0502	.0502	33
April	18	6	11	1	0	4.65	119.81	1.9212	.5640	.0	33
May	3	1	2	0	0	1.11	15.20	.1432	.0958	.0	33
June	0	0	0	0	0	1.03	6.71	.0	.0	.0	0
July	0	0	0	0	0	.47	4.72	.0	.0	.0	0
August	3	1	2	1	0	5.49	16.74	.1290	.0	.0429	33
September	0	0	0	0	0	2.46	19.33	.0	.0	.0	0
October	5	1	0	1	0	23.40	89.61	.3370	.0	.0675	20
November	6	0	0	2	0	14.69	48.13	.3942	.0	.1315	0
December	0	0	0	0	0	3.91	8.16	.0	.0	.0	0
	128	49	35	15	0	....	....	....	....	....	38.3

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP GORDON.

Camp Gordon, Ga., was situated on rolling ground previously occupied by small farms, within 10 miles of Atlanta, a city of over 150,000 inhabitants. It was a National Army cantonment, receiving drafted men from Alabama, Georgia, and Tennessee, but also contingents of considerable size from other camps.[10] In November, 1917, the average strength for the month had reached 27,000. The 82d Division moved overseas from here about May, 1918, but this did not materially reduce the average monthly strength, which

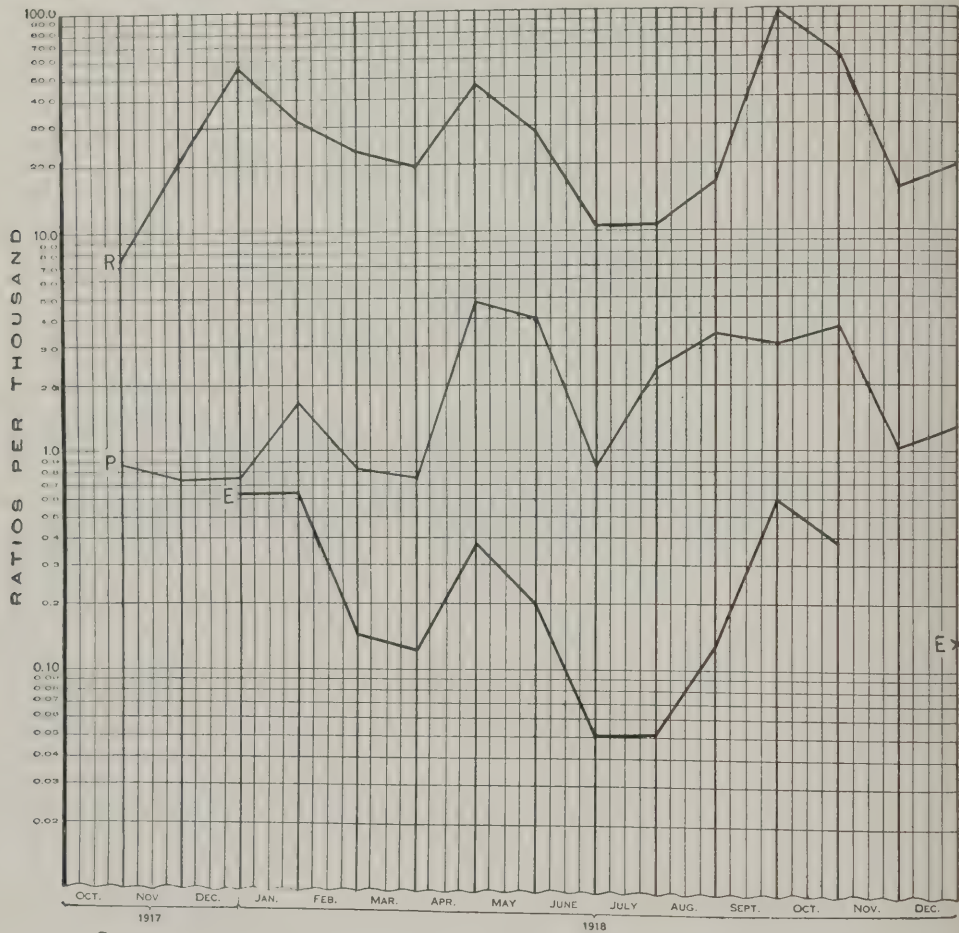


CHART XX.—Epidemiological chart for Camp Gordon, Ga., in monthly ratios per thousand men.

was maintained at from 27,000 to 46,000 by fresh accessions of drafted or transferred men.[10] Colored troops were included almost from the start.

The troops were quartered in frame barracks, which were heated with stoves, and poorly ventilated in cold weather.

Cases of measles were numerous during the last three months of 1917 and January, 1918, aggregating 1,051 cases for that period and 2,288 for the 15 months to and including December, 1918.[11] The postmeasles empyema cases are recorded in the special empyema reports as 27 for the first four months, with 18 deaths, and 13 for the remaining 11 months, all surviving.[12] In the

early period the mortality was, therefore, nearly 67 per cent; in the later, nil. Among the fatal cases (18) there are bacteriological records for 13. They were all associated with streptococci. Of the surviving (nine) cases in the earlier period, seven were streptococcic; in one a staphylococcus was found; and for the remaining case no data are given. Finally, among the 12 cases subsequent to January, 1918, 7 were associated with streptococcus, 2 with pneumococcus, Type IV, and for 3, data are lacking.

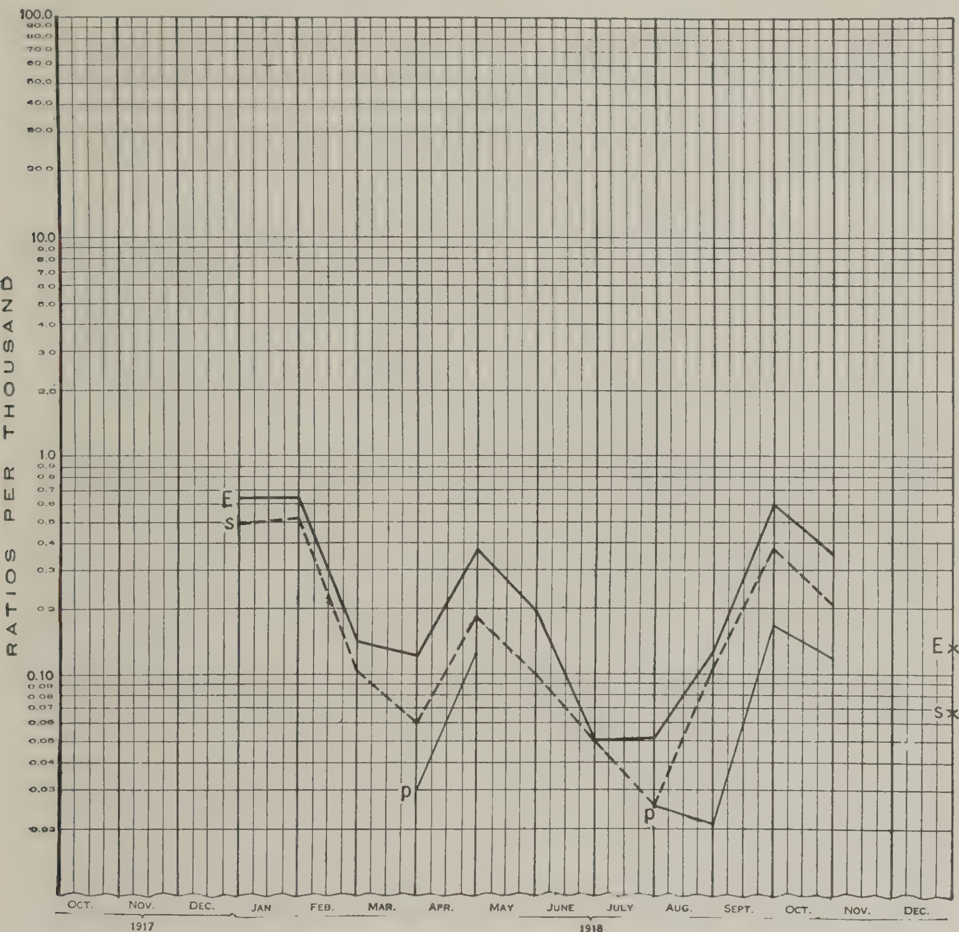


CHART XXI.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Gordon, Ga.

In the aggregate, 1.7 per cent of the total number of measles cases developed empyema, but of the postmeasles pneumonia cases, which were 119 for the whole period, 33.6 per cent were complicated with empyema, and, inferentially, the streptococcus must have been an important causative agency in the incidence of pneumonia among patients with measles.

No cases are recorded as following either mumps or scarlet fever, although there were nearly 5,000 admissions for the former disease.[12] The admissions for scarlet fever were only 10 for the whole period of 15 months.[12]

The number of cases of empyema, preceded by "colds," the exact character of which can not be stated, is considerable.

On Chart XX the similarity between the curves "R" and "E" is very striking, but in the early portion of "E" the excursions are exaggerations of those exhibited by "R." An explanation of this may be sought by inquiry into the nature of the diseases represented by the curve "R." As was the case at both Camp Sevier and Camp Wheeler, influenza was particularly prevalent at Camp Gordon in April, when there were 887 admissions classed as such. But there was also a high incidence in December, 1917, when 724 cases were reported. Since influenza throughout all the camps, with the possible exception of Camp Lee, appears to have predisposed to empyema, the high incidence of empyema in December and April may be correlated with that of influenza, added to the upper respiratory affections prevailing at the time. Cases of influenza were also relatively numerous in January and in May, but less so than in the months immediately preceding these.

Reference is especially made to the preponderance of streptococcus infections in December, January, and February, notwithstanding the prevalence of influenza, as contrasted with the advent of pneumococcus cases in March and April, which were then in about the same proportion to the streptococcus cases as in August and September, when influenza again showed a rise in incidence.

The curve of upper respiratory diseases never fell to quite 1 per cent of the command at Camp Gordon, and though the empyemata fell to a minimum with the lowest incidence shown by "R" in June and July, they did not entirely disappear. The histories of the four cases falling within these two months do not differ essentially from those of cases which developed at other times.

TABLE 14.[a]—*Epidemiological table for Camp Gordon, Ga.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	0	0	0	0	0	0.89	7.48	0	0	0	0
November	0	0	0	0	0	.74	20.99	0	0	0	0
December	22	12	17	0	0	.76	56.70	0.6388	0.4936	0	55
1918.											
January	21	13	17	0	0	1.67	31.99	.6444	.5216	0	62
February	4	0	3	0	0	.81	22.98	.1404	.1053	0	0
March	4	0	2	1	0	.75	19.51	.1200	.0600	0.0300	0
April	12	2	6	1	0	4.79	46.68	.3696	.1848	.1232	17
May	6	0	3	0	0	3.98	28.36	.1993	.0993	.0	0
June	2	1	2	0	0	.86	10.46	.0506	.0506	.0	50
July	2	0	1	1	0	2.39	10.93	.0511	.0255	.0255	0
August	6	0	5	1	0	3.36	16.98	.1263	.1052	.0210	0
September	25	3	16	7	0	3.05	96.06	.5910	.3786	.1656	12
October	12	1	7	4	0	3.60	60.42	.3577	.2086	.1192	8
November	0	0	0	0	0	1.18	15.56	.0	.0	.0	0
December	2	0	1	0	0	1.29	19.97	.1328	.0664	.0	0
	118	32	80	15	0	....	....	....	....	....	27.1

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP McCLELLAN.

Camp McClellan, Ala., situated about 4 miles from Anniston, a city of approximately 14,000 inhabitants, was first used by the National Guard from New Jersey, Virginia, Maryland, and the District of Columbia, with small additions from other camps.[10] During the month of December, 1917, the strength

reached approximately 27,000.[10] The number of colored troops was negligible until September, 1918, when 2,480 arrived, chiefly if not wholly from Alabama.[10]

The men were quartered in tents.[10]

The total admissions for measles for the 15 months beginning October, 1917, was 939, 24 of which were complicated with pneumonia.[11] The months of highest incidence were December, 1917 (120 cases), January (168), and September, 1918 (184), but no cases of postmeasles empyema are recorded for these

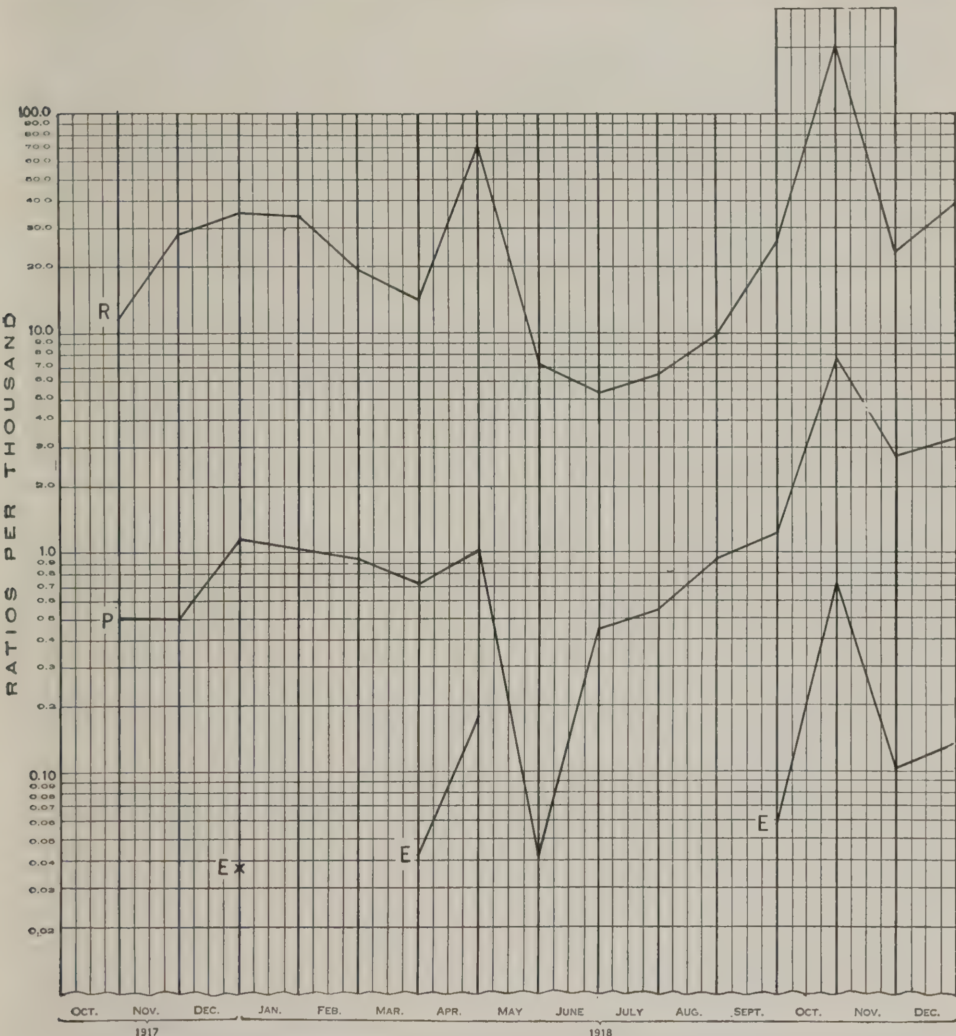


CHART XXII.—Epidemiological chart for Camp McClellan, Ala., in monthly ratios per thousand men.

months.[12] In fact, the only case of empyema reported as following measles was admitted November 29, 1918, when the incidence of measles had fallen to 84, with only 4 cases of pneumonia, all lobular. Bacteriological data concerning this single case are lacking.[11]

There were no cases preceded by either mumps or scarlet fever.[11]

The total incidence of empyema at Camp McClellan was small.[12] Were it not for the postinfluenzal accession of cases the number would appear negligible.

Until the beginning of March, 1918, the special empyema records contain only 2 cases. This number must, however, be supplemented by at least 4, for the reply, dated March 8, to the questionnaire of February 21 gives 6 cases, all following lobar pneumonia, of which there had been 92 within the same period. The organisms obtained from the pleural fluids were streptococcus, 2; pneumococcus, Type II, 1; Type IV, 1; influenza bacillus, 1; and mixed, 1. The cases included in the special empyema records were both associated with streptococcus and may be identical with the two of like association contained

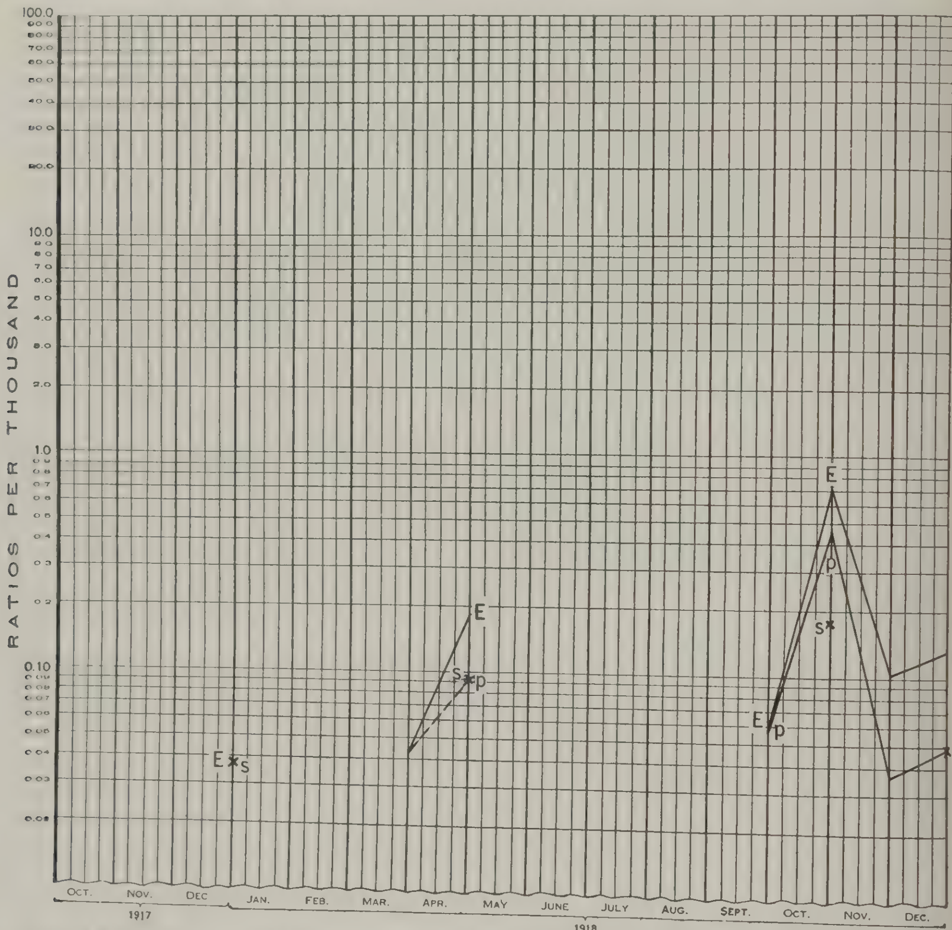


CHART XXIII.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp McClellan, Ala.

in the reply. During the high postinfluenzal incidence of empyema the streptococcus was not prominent, nor did it play a conspicuous part at any time.

The high peak shown for April on the chart coincided with a sudden increase in cases of influenza, which reached 1,277 in that month, although only 84 in March and 107 in May. The slight effect this outbreak had upon the incidence of the pneumonias, and the abrupt drop in the number of pneumonia cases to an extraordinarily low minimum immediately afterwards, are very striking.

Notwithstanding the small total number of empyema cases at Camp McClellan, their distribution in time closely follows the incidence of common respiratory diseases and become nil when this incidence falls below 1 per cent.

TABLE 15.[a]—*Epidemiological table for Camp McClellan, Ala.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	0	0	0	0	0	0.52	12.28	0	0	0	0
November	0	0	0	0	0	.51	28.06	0	0	0	0
December	1	0	1	0	0	1.26	35.89	0.0367	0.0367	0	0
1918.											
January	0	0	0	0	0	1.09	34.33	0	.0	0	0
February	0	0	0	0	0	.94	19.21	0	.0	0	0
March	1	0	1	0	0	.72	15.81	.0432	.0432	0	0
April	4	0	2	2	0	1.06	71.89	.1851	.0920	.0920	0
May	0	0	0	0	0	.04	7.26	.0	.0	.0	0
June	0	0	0	0	0	.45	5.40	.0	.0	.0	0
July	0	0	0	0	0	.56	6.55	.0	.0	.0	0
August	0	0	0	0	0	.95	9.95	.0	.0	.0	0
September	1	0	0	1	0	1.38	26.24	.0580	.0	.0581	0
October	20	0	5	13	0	7.66	209.80	.7148	.1785	.4650	0
November	3	0	0	1	0	2.86	24.44	.1130	.0	.0377	0
December	3	1	1	1	0	3.24	30.97	.1476	.0493	.0493	33
	33	1	10	18	0	....	....	....	....	....	3

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP SHERMAN.

Camp Sherman, Ohio, close to Chillicothe, with approximately 15,000 inhabitants, was used for drafted men of the National Army from Ohio and western Pennsylvania, with a small contingent from Oklahoma.[10] The strength for December, 1917, was approximately 34,500, but was not far below this figure in the preceding October.[10] The 83rd Division left for overseas about June, 1918, after which Camp Sherman became a replacement camp, receiving men from Tennessee, Indiana, West Virginia, and Alabama, as well as from Ohio and Pennsylvania.[10] After October, 1917, there were from 2,000 to 8,000 colored troops present in camp.[10]

Two-story frame barracks were provided for quarters and at times were overcrowded, kitchens and mess halls being used as sleeping quarters.[10]

There were 1,714 cases of measles at Camp Sherman during the 14 months beginning October, 1917, but this disease was most prevalent in January and February, 1918, when 859 cases were admitted.[11] It was during these two months that postmeasles empyema displayed the highest incidence, 10 cases out of a total of 12 falling within this period. Seven of these died, a mortality of 70 per cent. Yet the proportion of empyema to measles was less than 1.2 per cent. The other 2 cases of postmeasles empyema fell in December, 1918, when measles cases were reported at 55. Bacteriological data are missing with respect to 2 cases, but the other 10 were all associated with streptococcus. Indeed, during the period including December, 1917, to April, 1918, out of 54 bacteriological examinations 51, or 94 per cent, showed that the empyema was streptococcic, with only 6 per cent associated with pneumococcus. These figures are derived from the special empyema reports,[12] and are in substantial accord with data obtained through other and more contemporaneous sources.

There were no cases following mumps.

Two followed scarlet fever in April, 1918, with an intervening lobar pneumonia and with streptococci in the pleural fluids. The total cases of scarlet fever for 1918 numbered 329.[11]

The curve for respiratory diseases other than pneumonia (R) on the chart for Camp Sherman shows a high incidence from January until May. This high incidence is largely due to the elevated ratio for influenza during these months, though common respiratory diseases exhibited a similar increase during this time. Possibly it was difficult to separate the two and decide upon the proper group in which to place a given individual case. The fact remains, however, that many cases of influenza were recorded. This is of interest because the bacteriological reports indicate such a great preponderance of streptococci. It may be inferred from this and similar observations in other camps that in the fall of 1917 and in the early months of 1918 the streptococcus was unusually prevalent, and further, that at this time the high incidence of diseases of the upper respiratory tract was associated with organisms of the streptococcus group.

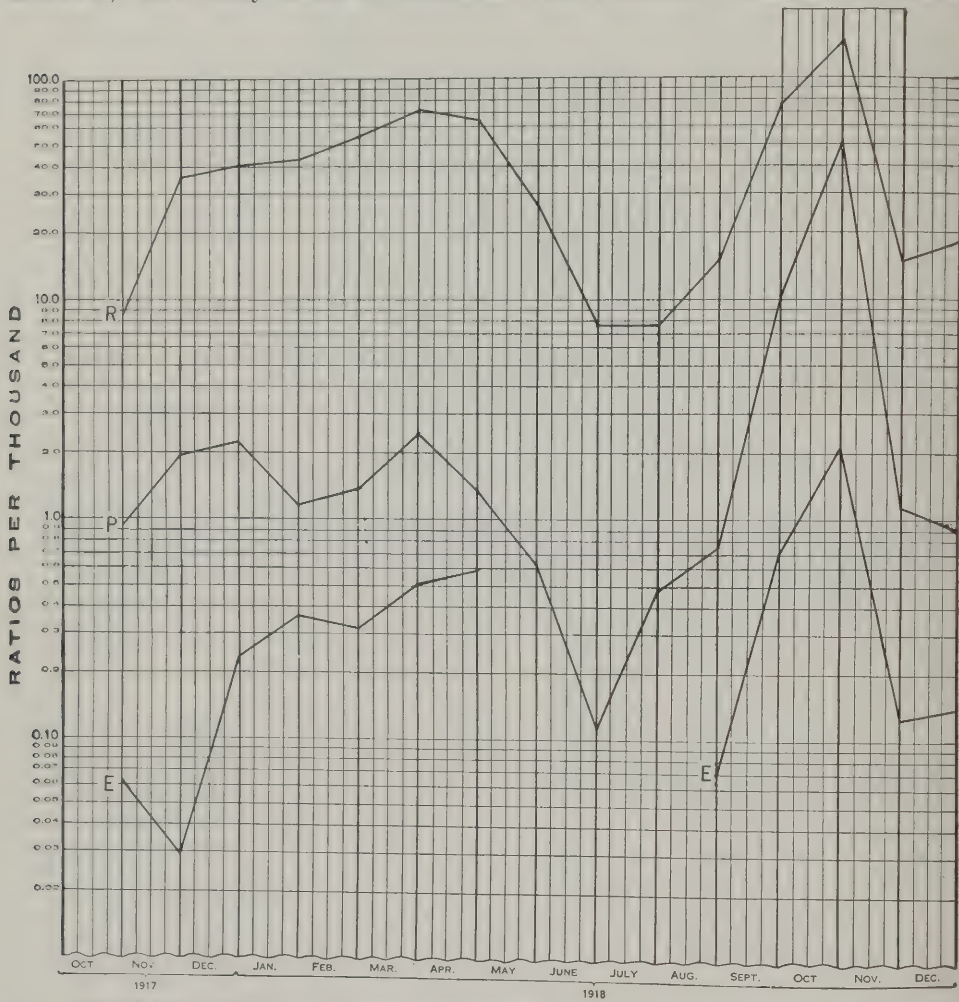


CHART XXIV.—Epidemiological chart for Camp Sherman, Ohio, in monthly ratios per thousand men.

The abrupt cessation of empyema after a period of high incidence and also the drop in pneumonia when the incidence of common respiratory diseases fell in May and June are very striking. Empyema did not reappear until August, when the admissions for diseases of the upper respiratory tract again exceeded 1 per cent of the command.

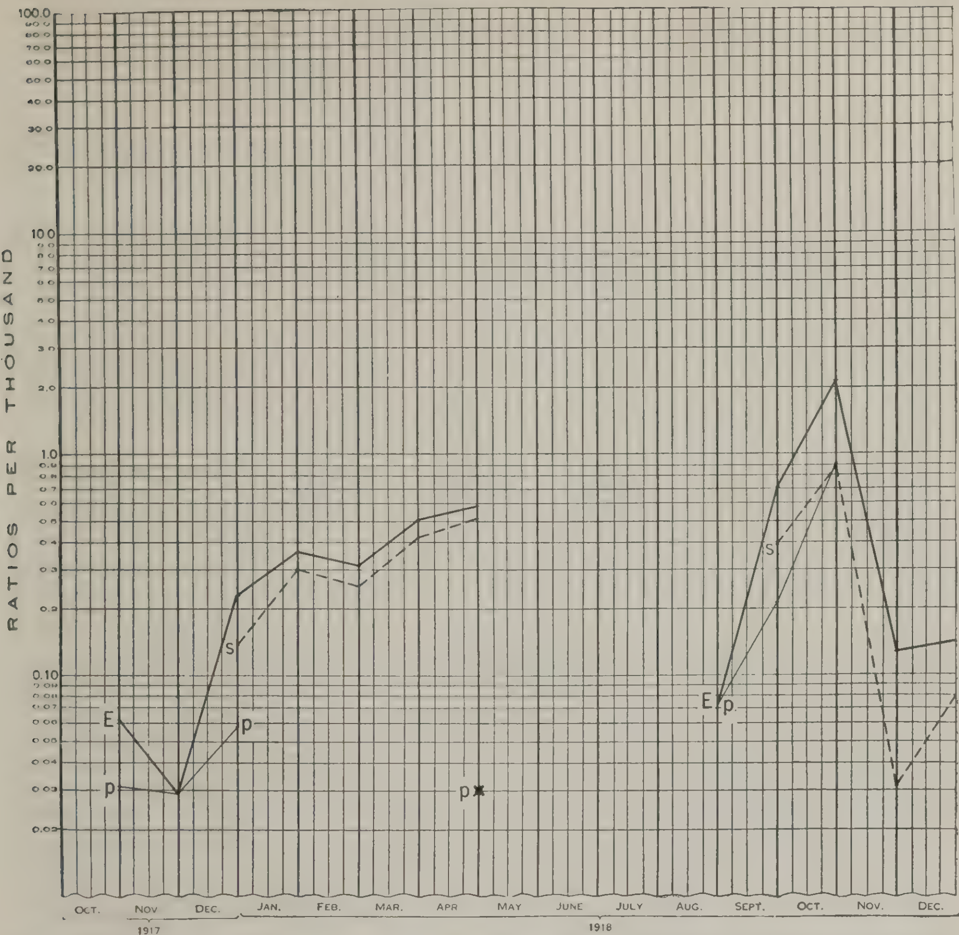


CHART XXV.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Sherman, Ohio.

TABLE 16.[a]—*Epidemiological table for Camp Sherman, Ohio.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	2	0	0	1	0	0.95	8.41	0.0630	0	0.0315	0
November	1	1	0	1	0	1 90	35.01	.0290	0	.0290	100
December	8	6	5	2	0	2.35	40.27	.2312	.1441	.0577	75
1918.											
January	12	8	10	0	0	1.26	43.43	.3663	.3055	.0	67
February	10	5	8	0	0	1.44	56.77	.3172	.2521	.0	50
March	13	7	11	0	0	2.53	71.78	.5091	.4240	.0	54
April	18	9	17	1	0	1.48	65.46	.5810	.5190	.0305	50
May	0	0	0	0	0	.63	27.62	.0	.0	.0	0
June	0	0	0	0	0	.12	7.62	.0	.0	.0	0
July	0	0	0	0	0	.49	7.63	.0	.0	.0	0
August	2	0	0	2	0	.77	10.63	.0716	.0	.0716	0
September	22	10	12	7	0	10.11	77.73	.7058	.3850	.2245	45
October	73	40	30	31	0	51.39	154.59	2.1264	.8773	.9050	55
November	4	3	1	0	0	1.29	16.30	.1310	.0328	.0	75
December	2	1	1	0	0	.90	18.28	.1441	.0793	.0	50
	167	90	95	45	0						53.8

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP CUSTER.

Camp Custer, Mich., located 5 miles from Battle Creek, a manufacturing city with a population of about 30,000. The camp was about $4\frac{1}{2}$ miles long, situated on a ridge roughly parallel to the Kalamazoo River. It was a National Army camp, the drafted men coming from Minnesota and the eastern part of Wisconsin, which includes the city of Milwaukee, with nearly 430,000 inhabitants.[10] The strength of the camp was about 24,000 men in December, 1917, and was maintained at about this, or a somewhat higher figure, until July, 1918, the approximate time of departure of the 85th Division.[10] In April a contingent of 2,000 men was received from Alabama, and early in the summer there were transfers hither from camps in North Dakota and West Virginia.[11] There were colored troops as early as December, 1917, but the number was small until the middle of 1918.[10]

The enlisted men were quartered in two-story frame barracks. In general, the health of the command was good, the admission rate for all diseases being comparatively low. Notwithstanding this good showing, the respiratory diseases were at times high, and this is attributed, by contemporary observers, to the arrival of fresh troops from places previously suffering from such complaints.[11] Colds, sore throat, and tonsillitis became prevalent after such accessions, often aggravated by long journeys in crowded trains and attended with fatigue and loss of sleep. Such conditions were obviously not confined to this particular camp. Many sudden outbreaks of measles elsewhere were attributed to like circumstances. Their consideration is not germane to the present study as it appears clear that measles is not in itself closely associated with the incidence of empyema. For this reason attention has not been called to such occurrences. But it has already become evident that certain infections of the upper air passages are potent factors in determining the occurrence of empyema, and this is a reason for dwelling somewhat on the experience at Camp Custer, where definite studies in this direction were undertaken.[23] The table and graphic charts for Camp Custer illustrate the relationships referred to.

It is of interest to note that there were 20 cases of postmeasles empyema between December 4, 1917, and February 15, 1918,[11] a period during which there must have been somewhat less than 443 cases of measles, for that is the number of admissions for this disease for the whole of December, 1917, January and February, 1918. The ratio between empyema and measles, taking this figure, would be over 4.5 per cent, an unusually high proportion. This could not have been because of special virulence of the measles or peculiar susceptibility to this disease on the part of the men, for the total number of cases of measles for 15 months was 794 and of the measles-pneumonias for the three months in question only 2, and of measles with other complications, 82.[11] The explanation is to be sought in the nature of the infections fortuitously associated with the measles as well as with other diseases. Thus, there are 6 cases, in which pneumonia was not noted, that were admitted with such varying diagnoses as "suspected spinal meningitis," "acute catarrhal stomatitis," "intestinal autointoxication," "rheumatic fever," "mitral stenosis," and "septicemia" (2 cases). Empyema was discovered within a few days after the admission of these cases; the first 3 recovered, the remaining 3 died. Such occurrences point to underlying causes, as was particularly recognized by medical officers in Camp Custer at

the time. The most potent factor was considered by them to be infections of the upper respiratory tract by streptococci, most commonly of the hemolytic variety.[23]

Only 1 case of empyema followed mumps, although there were 1,800 admissions for this disease.[11]

No postscarlatinal cases are included in the special empyema records.[12]

As must follow from the foregoing statements, the charts for Camp Custer show a very close parallelism between the curves of common respiratory diseases,

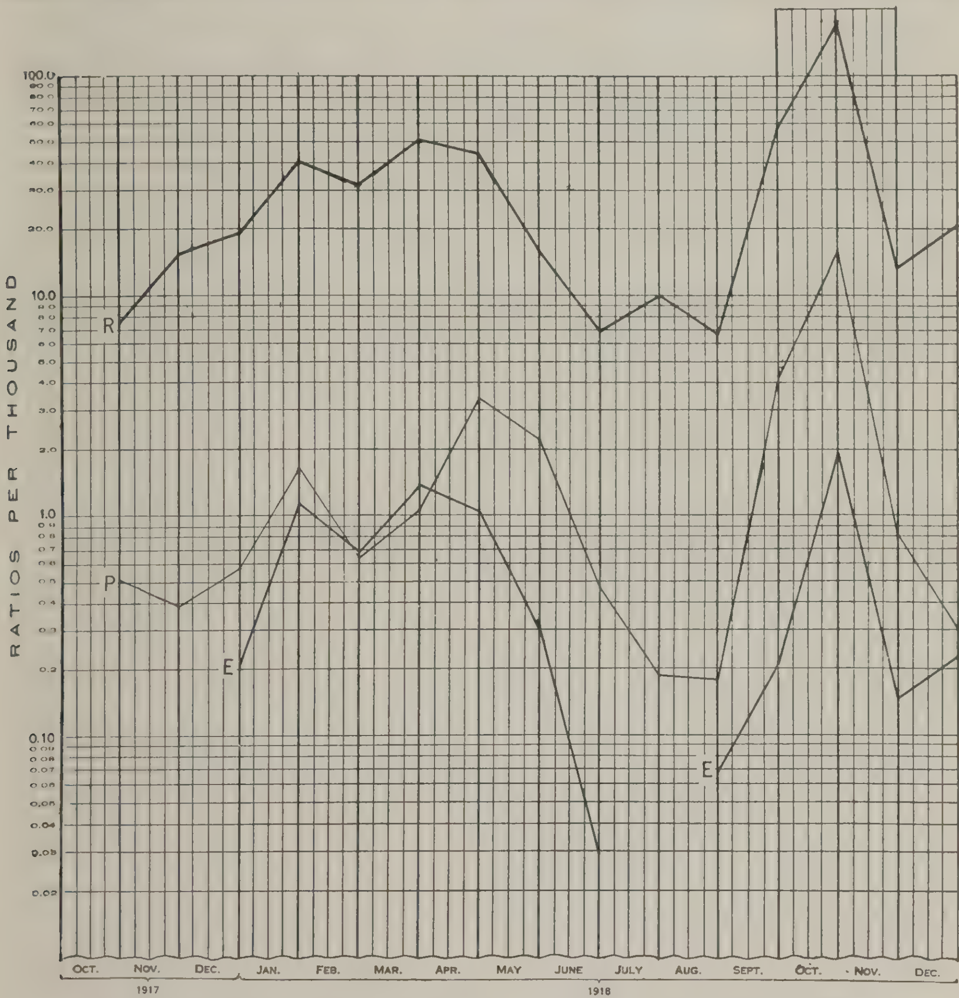


CHART XXVI.—Epidemiological chart for Camp Custer, Mich., in monthly ratios per thousand men.

empyema, and streptococcus, while the curve of the pneumonias takes an almost independent course until August, when it also partakes of the general character of the other three. It is particularly noteworthy that the incidence of lobar and broncho pneumonia combined falls below that of empyema in February, an almost unique occurrence and very striking, when the high incidence of affections of the upper air passages at this time is taken into account.

Again, there is a break in the empyema curve, when "R" falls below 1 per cent, but this is not so exact in time as has often been observed in other camps

This circumstance directs attention to the nature of the single case of empyema in June and the 2 cases in August, when the respiratory curve exhibits minima.[12]

The first of these 3 cases was admitted June 11, with bronchopneumonia extending over the whole right lung. Aspiration, 18 days later, showed the presence of pus on the right side, and examination of this exudate revealed pneumococcus, Type II. Three days later there was a costectomy of the ninth rib in the postaxillary line, and 800 c. c. of thick pus were removed. The wound closed about three weeks later, and the soldier returned to duty

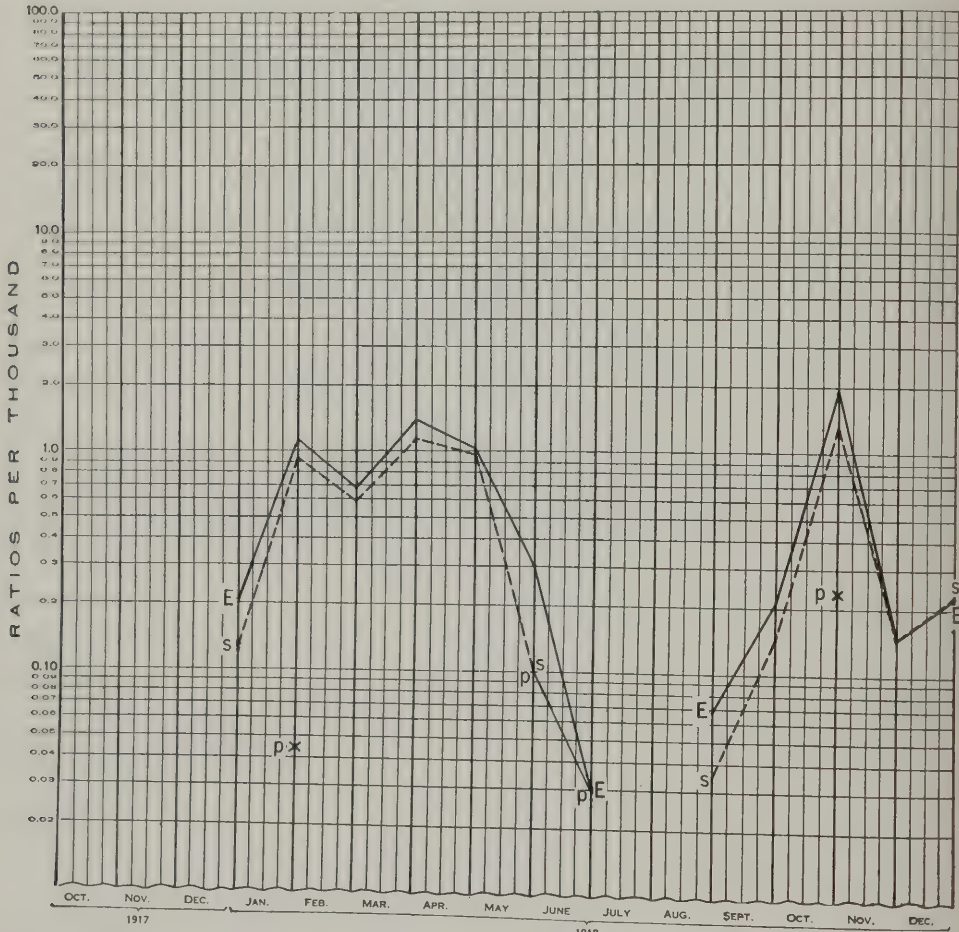


CHART XXVII.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Custer, Mich.

two months after entering the hospital. The case was evidently mild and followed a simple and normal course toward speedy convalescence without complication. It resembles the sporadic cases of pneumococcus empyema common in civil life.

The first case in August was admitted on the 2nd of the month with acute catarrhal bronchitis.[12] No definite diagnosis of pneumonia was ever recorded, but aspiration 25 days after admission resulted in 20 c. c. of straw-colored fluid. Nine subsequent aspirations, at which amounts of fluid varying from

50 c. c. to 2,000 c. c. were withdrawn, were made at different intervals until finally, on the one hundred twenty-second day, a portion of the ninth rib was removed, and a seropurulent fluid evacuated. About seven weeks later it was determined that the case was tuberculous. The patient was transferred to General Hospital No. 12, where the wound closed, and the man returned to duty, but was subsequently admitted to the base hospital at Camp Sherman, and thence transferred to Fort McPherson. At one time streptococci (unclassified), and at another, hemolytic streptococci were reported as found in the pleural discharge, but these examinations were made nearly three months after the first aspiration, and can not be trusted as evidence of the nature of the primary infection, which was apparently tuberculous.

The second case in August was admitted on the 9th of that month, with right suppurative pleurisy following an accidental gunshot wound.

The last two cases in the above list certainly have no epidemiological value for present purposes, and the first departs materially in its clinical features from the cases occurring during the period of high incidence of empyema in the preceding months. The fact that these cases occurred when acute respiratory diseases were minimal in number does not militate against the general rule that empyemas are absent when upper respiratory diseases lead to admissions less in number than 1 per cent of the strength of the camp.

TABLE 17.[a]—*Epidemiological table for Camp Custer, Mich.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	0	0	0	0	0	0.52	7.56	0	0	0	0
November	0	0	0	0	0	.39	15.16	0	0	0	0
December	5	1	3	0	0	.59	19.35	0.2075	0.1244	0	20
1918.											
January	27	14	21	1	1	1.67	40.10	1.1389	.9198	0.0438	52
February	15	4	13	0	0	.64	31.29	.6824	.5915	.0	26
March	25	12	21	0	0	1.75	51.45	1.3774	1.1570	.0	48
April	26	10	25	0	0	3.36	44.18	1.0397	.9626	.0	38
May	9	4	3	3	1	2.15	15.91	.2999	.1000	.1000	45
June	1	0	0	1	0	.46	6.95	.0294	.0	.0294	0
July	0	0	0	0	0	.19	9.99	.0	.0	.0	0
August	2	0	1	0	0	.18	6.61	.0685	.0343	.0	0
September	8	2	5	0	1	4.38	58.54	.2086	.1408	.0	25
October	76	13	52	9	1	16.16	174.88	1.9284	1.3295	.2301	17
November	5	0	5	0	1	.82	13.03	.1448	.1448	.0	0
December	7	0	7	0	0	.30	20.81	.2239	.2240	.0	0
	206	60	156	14	5	....	....	....	....	....	29.1

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP GRANT.

Camp Grant, Ill., situated near Rockford, a manufacturing city of about 50,000 inhabitants, was used for the National Army. The drafted men first came from Illinois and Wisconsin, largely from urban homes.[10] In September, 1917, the strength averaged approximately 13,000, but rose to over 28,000 in November.[10] There were a few men transferred from other camps as early as October, 1917, and in March and April, 1918, contingents of from 1,000 to 3,000 were received from Idaho, North Carolina, Louisiana, South Dakota, and

Nebraska.[10] In consequence the urban class must have become less dominant after these accessions. There were nearly a thousand colored troops in November, 1917, and from that time their number increased, ranging from 3,000 to 8,000 until September, 1918, when they reached 10,000, about one-fifth of the total number of enlisted men.[10]

Barracks served as quarters for the troops.

The noneffective rate in the early months was very low, being next to that at Camp Upton, where it was least of all. This is in harmony with the fact that the men at both these camps were drawn chiefly from large cities. With the arrival of colored troops admissions for measles became augmented, though they were never conspicuously large as compared with some of the southern camps.[11]

The total admissions for measles for the 15 months including and following October, 1917, was 1,006; the largest number for any month was 391 in January, 1918. The number of postmeasles empyema cases reported in the special empyema records for the 15 months was nine, with two deaths.[12] Of the total measles cases, less than 1 per cent developed empyema. In January, 1918, there were four postmeasles empyema cases, a trifle over 1 per cent of the measles in that month. Two of these cases were associated with streptococcus (one death), and two with staphylococcus, both recovering.[12]

One fatal case of empyema followed mumps, in February, 1918, when there were 226 admissions for the latter disease, nearly the highest incidence for the whole period of 15 months, the highest (278 cases) falling in December, 1918.[12]

Two postscarlatinal empyema cases are recorded for late February and early March, both associated with streptococcus and both surviving. At that time there were relatively many admissions for scarlet fever, the totals being 38 in February and 20 in March, out of 188 for the 15 months.[11]

There are 118 cases of empyema for which bacteriological data are given, out of a total of 134 cases, representing 88 per cent, and may be accepted as representing the general character of the infections. During the early period of high incidence streptococci were found nearly three times as often as pneumococci, but there are three cases reported as associated with staphylococcus, an unusually high number, making 8 per cent of the total positive findings during this period. In the fall of 1918 the streptococci are only about one-third more frequent than pneumococci. This falling off in the preponderance of streptococci in the later period, as compared with the earlier period of high incidence, was an almost universal experience throughout all the camps.[12]

The approximate constancy of the ratio between empyema and diseases of the upper respiratory tract is clearly shown by Chart XXVIII. In contrast to this is the irregular course of the pneumonia curve. The lapse of empyema is complete in June, but the curve "R" falls below 1 per cent in June, July, and August, and this circumstance calls for inquiry into the histories of the four cases of empyema occurring within these three months.[12]

The first of these was admitted May 18, with bilateral follicular tonsillitis. This was speedily followed by pleurisy on the left side. On the 18th day after admission 550 c. c. of a cloudy fluid were aspirated from the left pleural cavity, and the following day upon resecting a portion of the eighth rib 500 c. c. of a seropurulent fluid were evacuated. The wound had closed by the end of the

fourth month after admission, and the patient returned to duty shortly afterwards. The organism in the pleural exudate was a streptococcus. No clinical evidence of pneumonia was recorded in the history of this case, and it is evident that it was most intimately associated with an infection of the upper respiratory tract, although the incidence of these infections at the time was rapidly waning.

The second case in this series was admitted July 6, with a lobar pneumonia of the left lower lobe. Empyema was recognized on the 24th day after admission, and was treated by resection the day following. There is no record of the

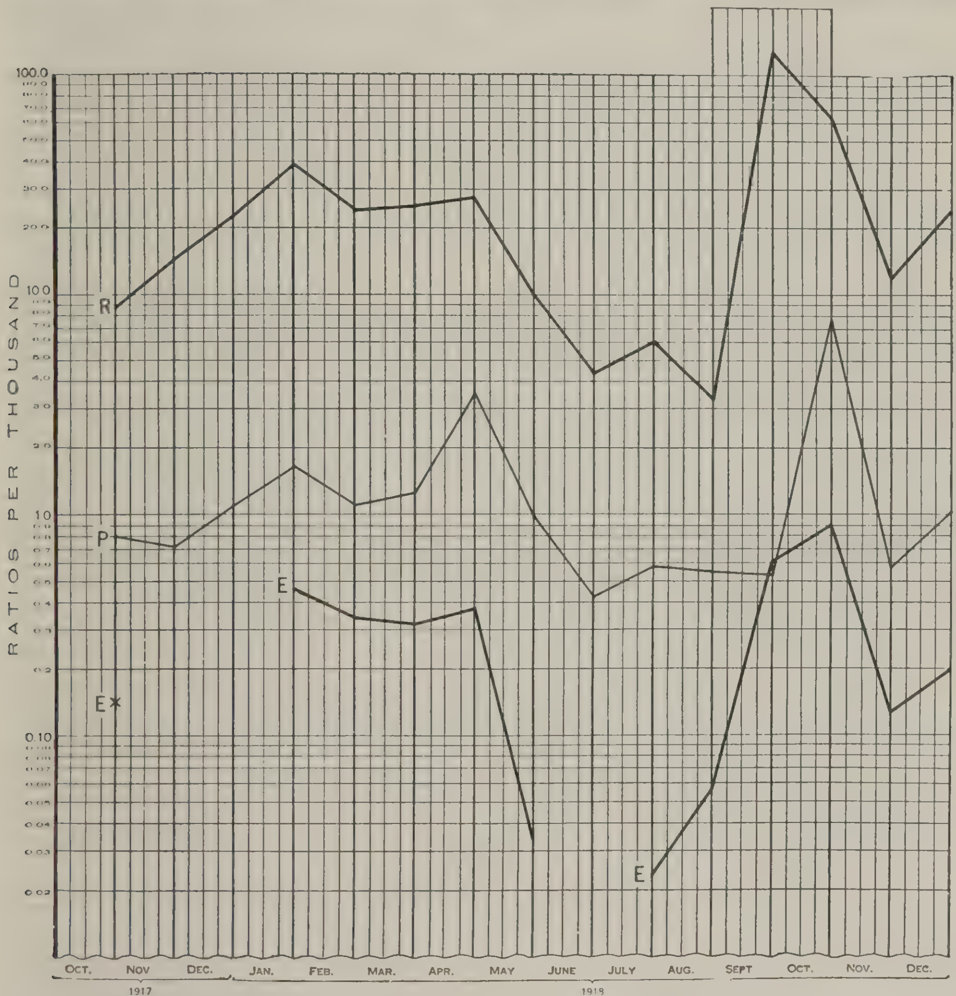


CHART XXVIII.—Epidemiological chart for Camp Grant, Ill., in monthly ratios per thousand men.

amount or character of the fluid, but convalescence appears to have been uninterrupted and the patient returned to duty, and about a year later wrote that he was fireman in a hotel. Pneumococci were obtained from the pleural exudate.

The third case, admitted August 5, for appendicitis, had an appendectomy four days later, and 10 days thereafter developed an empyema that was speedily cured after resection. The seropurulent exudate contained pneumococci. About a year later he was employed in a laundry and complained of no disability. This case almost certainly followed general anesthesia.

Finally, the fourth case was admitted August 3, as "suspected lobar pneumonia." Pus was discovered in the left pleural cavity on the day of admission and rib resection was done five days later. The exudate contained pneumococci. About five weeks later an abscess in one of the abdominal muscles was drained and the streptococcus viridans was cultivated from this pus. A week later purulent arthritis of the left knee developed, which was opened. Death occurred 62 days after admission. There was no autopsy. While it is not possible to discover the nature of the primary disease or the time of its occurrence, there

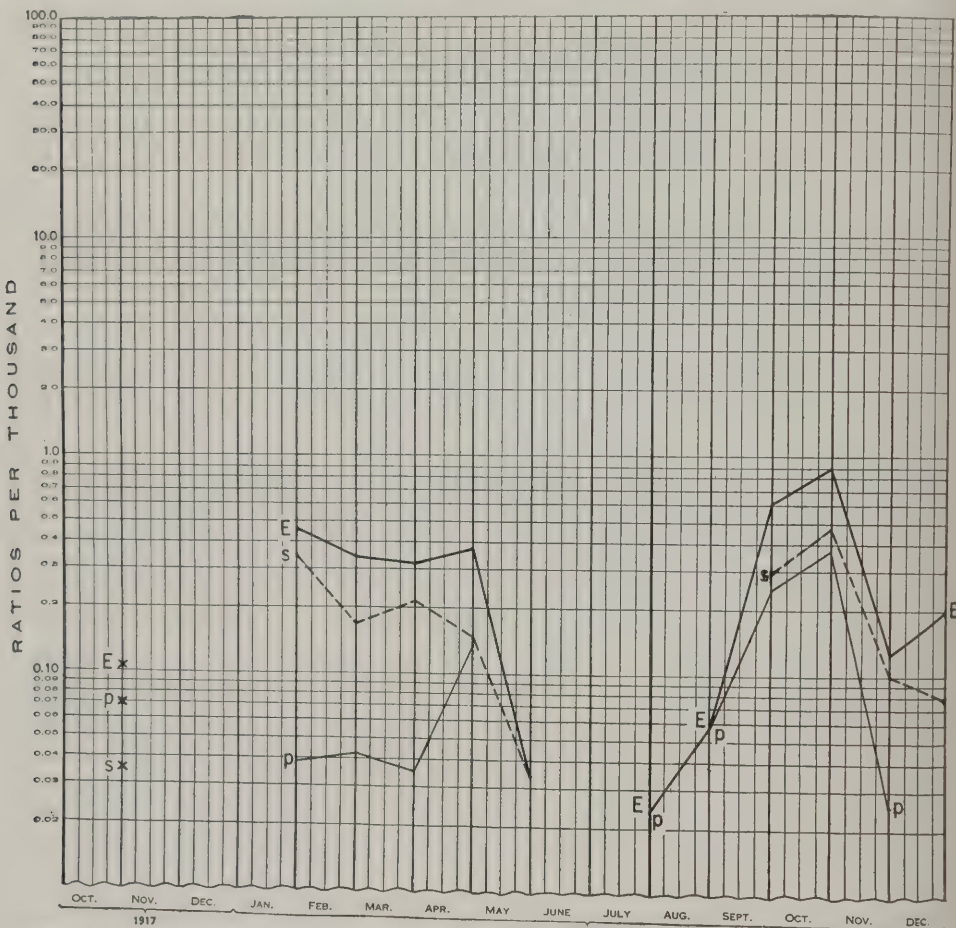


CHART XXIX.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Grant, Ill.

was evidently a latent empyema that had not been recognized for some time. Were the date of the primary disease known, the case would have been included among those occurring earlier.

From an epidemiological standpoint the case occurring in May presents an isolated instance of the persistence of conditions existing during the preceding period of high incidence, and its occurrence supports the general conclusion that throat infections are connected with those of the pleura.

The other cases require no special comment. They are of a character that may occur at any period of year in a community as large as this camp.

TABLE 18.[a]—*Epidemiological table for Camp Grant, Ill.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	3	0	0	2	0	0.80	8.72	0.1047	0.0349	0.0698	0
November	0	0	0	0	0	.73	14.16	.0	.0	.0	0
December	0	0	0	0	0	1.11	22.77	.0	.0	.0	0
1918.											
January	12	3	9	1	1	1.68	38.98	.4644	.3496	.0387	25
February	8	1	4	1	0	1.10	24.17	.3368	.1684	.0421	13
March	9	1	6	1	1	1.28	25.07	.3151	.2101	.0350	11
April	10	3	4	5	1	3.50	27.65	.3670	.1468	.1374	30
May	1	0	1	0	0	.98	10.02	.0331	.0331	.0	0
June	0	0	0	0	0	.42	4.34	.0	.0	.0	0
July	1	0	0	1	0	.58	6.04	.0235	.0	.0255	0
August	2	1	0	1	0	.56	3.28	.0572	.0	.0572	50
September	29	11	13	12	0	.53	126.11	.6010	.2901	.2487	38
October	50	6	26	21	0	7.65	63.35	.9068	.4716	.3734	12
November	4	1	3	1	0	.58	11.91	.1258	.1006	.0251	25
December	5	1	2	0	0	1.11	23.25	.1975	.0789	.0	20
	134	28	69	46	0						20.9

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP DODGE.

Camp Dodge, Iowa, on a sandy ridge about 10 miles from Des Moines, a city of about 100,000 inhabitants, was a National Army camp. A large majority of the drafted men came from Iowa, Illinois, Minnesota, and North Dakota, and were drawn from regions about 32 per cent urban.[10] But between the middle and the end of October, 1917, about 3,400 men arrived from Alabama, and from that time there were from 3,000 to 6,000 colored troops in camp throughout 1918.[10] In the early and middle summer of that year contingents were received also from Tennessee, Montana, South Dakota, and Indiana. In origin, the troops at this camp were far from homogeneous.

The enlisted men at this camp were quartered in frame barracks.

From the very beginning there was a rather high incidence of infectious diseases, measles, mumps, and scarlet fever, as well as lobar and bronchopneumonia, contributing a quota.[11]

The admissions for measles were 366 in the last three months of 1917; and in 1918 they reached 2,038, making a total of 2,409 for the 15 months. For the longer period, the postmeasles lobar pneumonia cases were reported as 12, and the bronchopneumonia cases as 22, or 34 in all. The postmeasles empyema cases do not fall short of this total, being 31, with 22 deaths, a mortality of 71 per cent.

On the other hand, the ratio between postmeasles empyema and total measles is under 1.4 per cent, leading to the inference that measles was not a strikingly predisposing disease, but that empyema, when complicating measles, was indicative of a very serious infection. Of the 9 surviving cases of postmeasles empyema there are bacteriological data concerning 7: streptococcus, 4; and pneumococcus, 3. Among the 22 fatal cases, the bacteriological findings are available in 17. Of these 17 fatal cases all were streptococcic; and 12 are specifically described as hemolytic, the question of hemolysis not being touched upon in the remaining 5 cases.[11] Considered in conjunction with the tabulated

record of all the empyemata at Camp Dodge the inference appears justified that the majority of the total cases of empyema were associated with virulent strains of streptococci and that the high mortality was largely owing to this circumstance.[12] There is no imperative reason why, in this respect, the post-measles cases should be segregated in a group by themselves. The statistics from other camps have already suggested this, but the large number of post-measles cases at Camp Dodge gives it a particular emphasis.

Only two cases of empyema are reported as following primary mumps, although there were 3,200 admissions for mumps.[11] In one case the organism was a hemolytic streptococcus, whereas, in the other case, the causative organism is unknown. Both survived.

Five postscarlatinal empyema cases occurred. The first in February, 1918, two in March, and two in April. The admissions for scarlet fever for those months were 43, 76, and 92, respectively.[11] Four of these cases yielded hemolytic streptococcus; no bacteriological record is given for the fifth.

The increased incidence of empyema in March and April, shown on Chart XXX as relatively greater than a corresponding rise in common respiratory diseases, coincides with a period when there was a considerably larger proportion of cases of influenza than during February and May. Presumably, influenza was of greater severity at that time. This is reflected in the preponderance among the empyemata of streptococcus infections, which rise proportionately to the rise in the empyema curve, while the pneumococcus cases remain about stationary.

The occurrence of several cases of empyema in July and August, amounting to six cases in the former month, and eight in the latter, at a time when diseases of the upper respiratory tract were at or close to the minimum for the year, is the most striking feature of this chart and, from an epidemiological standpoint, the most important. For this reason particular attention must be given to the nature of these 14 cases, as has already been done concerning cases occurring at unusual periods in other camps.

Of the six cases in July, three died. Two of these fatal cases were associated with streptococcus and one with pneumococcus, Type I. The bacteriological findings in the surviving three cases were the same: two streptococcus and one pneumococcus, Type I.

The histories may be given in a much abbreviated form as follows:[12]

1. Admitted July 7. Suspected lobar pneumonia. Empyema found on day of admission. Pneumococcus, Type I, in 150 c. c. fluid removed by aspiration. No operation. Returned to quarters on eighty-seventh day.

2. Admitted July 27. Measles. Pneumonia and empyema found three months later. Seven hundred c. c. purulent fluid contained hemolytic streptococci, influenza bacilli, and a few staphylococci. Treated by catheter drainage, and discharged from the Army on surgeon's certificate of disability four months later.

3. Admitted July 26. Acute catarrhal bronchitis. Lobar pneumonia on second day and empyema three weeks later with streptococci in seropurulent fluid. Thoracotomy. Death on forty-third day. At autopsy, acute hemorrhagic tracheitis and bronchitis, bronchopneumonia, general peritonitis, multiple abscesses of liver. General streptococcus infection.

4. Admitted July 25. Lobar pneumonia. No operation. Empyema revealed post mortem with pneumococcus, Type I, in pleural fluid. Acute hemorrhagic tracheitis and bronchitis, bilateral lobar pneumonia involving both lobes on the left and the lower right lobe.

5. Admitted July 30. Observation for measles. Lobar pneumonia about three weeks later, and empyema about three weeks after the pneumonia. Streptococcus in pleural exudate.

Pericarditis with effusion. Abscess under shoulder of side opposite to the empyema. Death on sixty-eighth day. No autopsy.

6. Admitted July 31. Measles. Bilateral bronchopneumonia. Empyema with hemolytic streptococci. Thoracotomy. Discharged on surgeon's certificate of disability on the two hundred and sixteenth day.

It will be observed that three of these cases followed measles and were all associated with streptococci. They resemble the cases occurring at periods

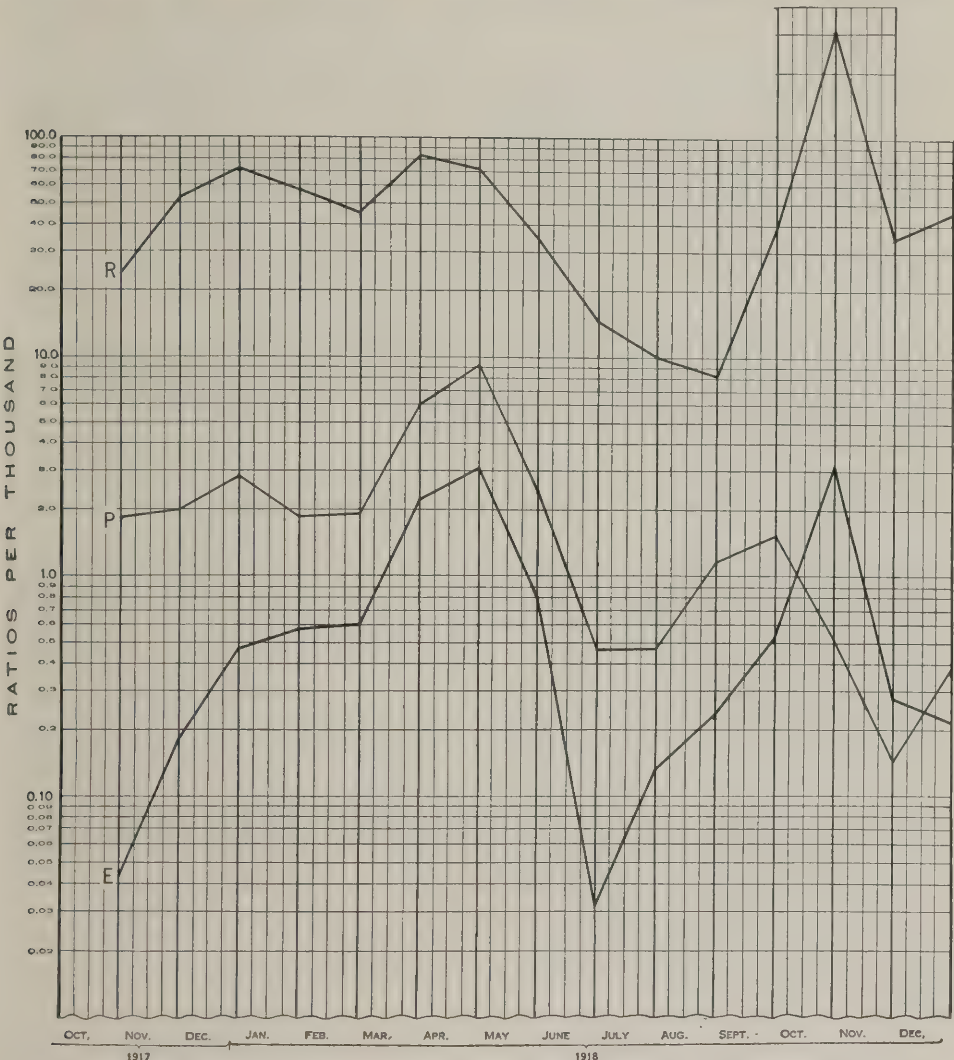


CHART XXX.—Epidemiological chart for Camp Dodge, Iowa, in monthly ratios per thousand men.

of high incidence and suggest a persistence in minor degree of the conditions determining the occurrence of empyema at such times notwithstanding the decrease of total incidence of upper respiratory diseases. It would be very enlightening were records available of bacteriological surveys of throat conditions at this time, as they might have revealed the existence of a considerable number of streptococcus carriers. Case 3 originated in the upper air passages and was also associated with streptococci. The remaining two (Nos. 1 and 4)

were Type I pneumococcus cases and are apparently unassociated with prevailing infections of the upper respiratory tract. Their epidemiological importance attaches more to the pneumonia than to the empyema complicating it.

Six of the eight cases originating in August died. There are only five among the eight cases concerning which there are positive bacteriological findings. In four of these, streptococci were found, suggesting the continued presence of carriers of this organism.

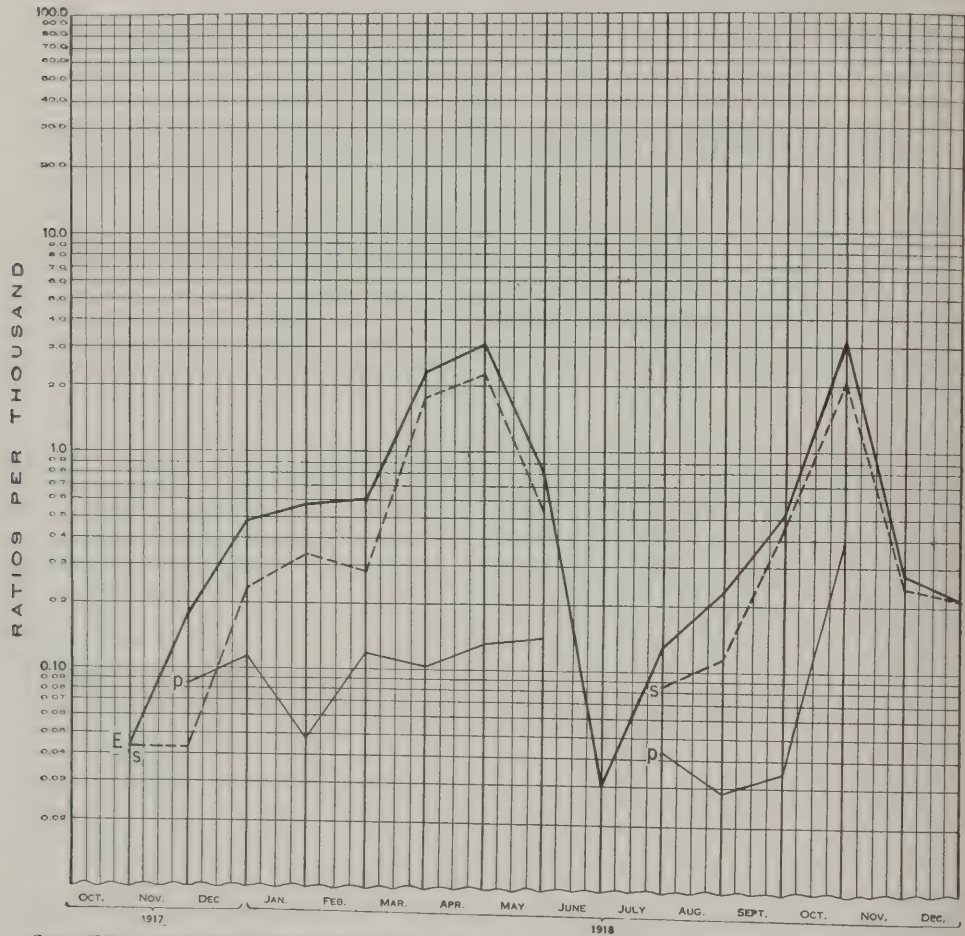


CHART XXXI.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Dodge, Iowa.

The following condensed histories of these cases are given, arranged in chronological order:[12]

1. Admitted August 1. Acute appendicitis. Lobar pneumonia and empyema developed almost simultaneously within a week. Thoracotomy three months later. Discharged on surgeon's certificate of disability, two hundred and sixty-sixth day. No report of bacteriological findings or concerning operation for appendicitis.

2. Admitted August 2. Measles; tonsillectomy; bronchopneumonia, empyema, not operated. No bacteriological report. Death on sixty-ninth day. No autopsy.

3. Admitted August 2. Vincent's angina. Bronchopneumonia sixty-fifth day. Died 70 days after admission. Empyema revealed on post-mortem. Autopsy: Acute hemorrhagic tracheitis and bronchitis, bronchopneumonia, bilateral empyema, purulent pericarditis. Hemolytic streptococci, in pleural fluid, pericardium and blood from cavity of heart.

4. Admitted August 4. Lobar pneumonia. Empyema with bloody serous fluid, third day. Death, fourth day. Autopsy notes lacking.

5. Admitted August 10. Observation for measles. Lobar pneumonia in 2 days, empyema in 20. Straw-colored fluid. Pneumococcus, Type IV. Treated by aspiration. No operation. Returned to quarters in two months.

6. Admitted August 12. For observation. Lobar pneumonia in three days, empyema (110 c. c. turbid fluid with pneumococcus, Type III, and non-hemolytic streptococcus) six days after admission, and death the same day. Autopsy: Bilateral lobar pneumonia, purulent tracheitis and bronchitis, bilateral empyema, purulent pericarditis. Pneumococcus, Type III, from left pleural fluid, non-hemolytic streptococci in right pleural fluid.

7. Admitted August 20. Phimosis and chancroid. Lobar pneumonia. Empyema with streptococci. Thoracotomy. Death 54 days after admission. No autopsy.

8. Admitted August 23. Acute suppurating bubo. Lobar pneumonia and empyema with aspiration of 300 c. c. pus containing hemolytic streptococci, eleventh day. No operation. Death 42 days after admission. Autopsy. Bilateral interstitial pneumonia, acute hemorrhagic tracheitis and bronchitis, empyema right side with 1,000 c. c. seropurulent fluid.

Although somewhat more abbreviated, as here given, the available histories of all these cases are meager. Cases No. 2 and No. 3 evidently started as serious throat infections; Case No. 2, and possibly Case No. 3, may have followed anesthesia. With regard to the remaining cases, it may be said that none was a typical pneumonia of classic nature. All, with the possible exception of Nos. 1 and 5, offer evidence of some underlying, severe infection, the exact nature of which is not revealed. The repeated report of acute processes in the trachea and bronchi do, however, call attention to the upper air passages as a site where such infections had found lodgment.

The very great prevalence of streptococci in this camp leaves little doubt that this was the infecting organism.

TABLE 19.[a]—*Epidemiological table for Camp Dodge, Iowa.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	1	0	1	0	0	1.83	23.54	0.0430	0.0430	0	0
November	4	3	1	2	1	2.01	53.08	.1777	.0427	0.0854	75
December	9	4	5	2	0	2.82	72.83	.4683	.2281	.1141	45
1918.											
January	12	6	7	1	0	1.83	57.45	.5680	.3313	.0473	50
February	13	8	7	3	0	1.94	45.96	.6030	.2777	.1190	62
March	64	48	49	3	0	6.04	84.52	2.2292	1.7038	.1043	75
April	69	46	51	2	0	9.26	72.33	3.0330	2.2418	.1319	67
May	23	16	15	4	0	2.48	34.93	.8096	.5397	.1408	70
June	1	0	0	0	0	.47	14.59	.0316	.0	.0	0
July	6	3	4	2	0	.47	10.07	.1290	.0860	.0430	50
August	8	6	4	1	0	1.16	8.29	.2296	.1148	.0287	75
September	15	12	13	1	0	1.51	38.78	.5237	.4546	.0349	80
October	105	58	72	13	6	.53	305.48	3.1334	2.0591	.3879	55
November	8	5	6	1	0	.14	34.88	.2740	.2406	.0	63
December	4	1	4	0	0	.38	45.21	.2125	.2125	.0	25
	342	216	239	35	7						63.1

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP PIKE.

Camp Pike, Ark., about 3 miles from Little Rock, a city with a population approximating 55,000, was a cantonment for the National Army.[10] The men were drafted from Arkansas, Louisiana, Mississippi, and the western part of Alabama, and were chiefly from rural homes, the relative urbanity of the territory from which they came being about 20 per cent.[10] There were colored troops almost from the start, varying from about a tenth to a third of the command.[10]

The enlisted men were quartered in barracks, which at times (chiefly in summer) were overcrowded. The general admissions for disease were high. Measles started in September (42 cases) and rapidly increased, reaching over 1,800 in November.[11] Mumps and scarlet fever were also prevalent.[11] There were 196 cases of scarlet fever in hospital on December 15, 1918.

The total admissions for measles during the 15 months ending with December, 1918, were 6,959. The special empyema records give the total of postmeasles empyema as 57 cases, a proportion of a little over 0.8 per cent of the total measles.[12]

Two cases of empyema were secondary to mumps.[12] Both were associated with hemolytic streptococci and both recovered. This is a negligible proportion of the total admissions for mumps, which numbered 6,462.

Following scarlet fever there were three cases of empyema,[12] all occurring in November and December, 1917. During these 2 months there was an epidemic of scarlet fever, the number of admissions amounting to 275.[11] The bacteriological history of the three cases of postscarlatinal empyema is uncertain.

In Table 20 the figures given for the associated bacteria are derived from the special empyema records[12] compiled at the base hospital. In the early period of high incidence these records indicate only a moderate preponderance of streptococci, but in the reply to the questionnaire of February 21, 1918,[9] transmitted from the base hospital March 23, it is stated that "Of the 85 cases (of empyema) giving positive findings in both culture and the stain, the following grouping is warranted: Streptococci, 63 (74 per cent); pneumococci, 22 (26 per cent). Of the various types of pneumococci we find the following: Type I, 2; Type II, 7; Type IV, 6; not agglutinated, 7." Further information concerning associated microorganisms is given by Maj. Hugh McKenna, M. R. C., then chief of the surgical service.[24] The cases he deals with occurred prior to April 27, 1918. The bacteriological findings were: Streptococcus hemolyticus, 101 (80 per cent); pneumococcus, 25: Type I, 2; Type II, 7; Type IV, 6; not typed, 10.

These sources of information are in accord respecting the preponderance of streptococci in the pleural exudates, and give ratios of 74 per cent and 80 per cent, respectively.

The foregoing data apply to the period prior to May, 1918. A member of the local empyema team reported 88 positive bacteriological findings in empyema cases during September, October, and the first half of November, 1918.[25] There were 61 (69 per cent) associated with streptococci, and 27 (31 per cent) with pneumococci.

All the available evidence indicates a great preponderance of streptococci throughout the history of the camp. This is reflected in the streptococcus curve on Chart XXXIII, which, however, is placed too low at many points. It is not possible to make corrections, for the contemporary reports do not contain figures for individual months.

In commenting upon the curves on Chart XXXII there are few points not touched upon already to which attention may be directed. The high

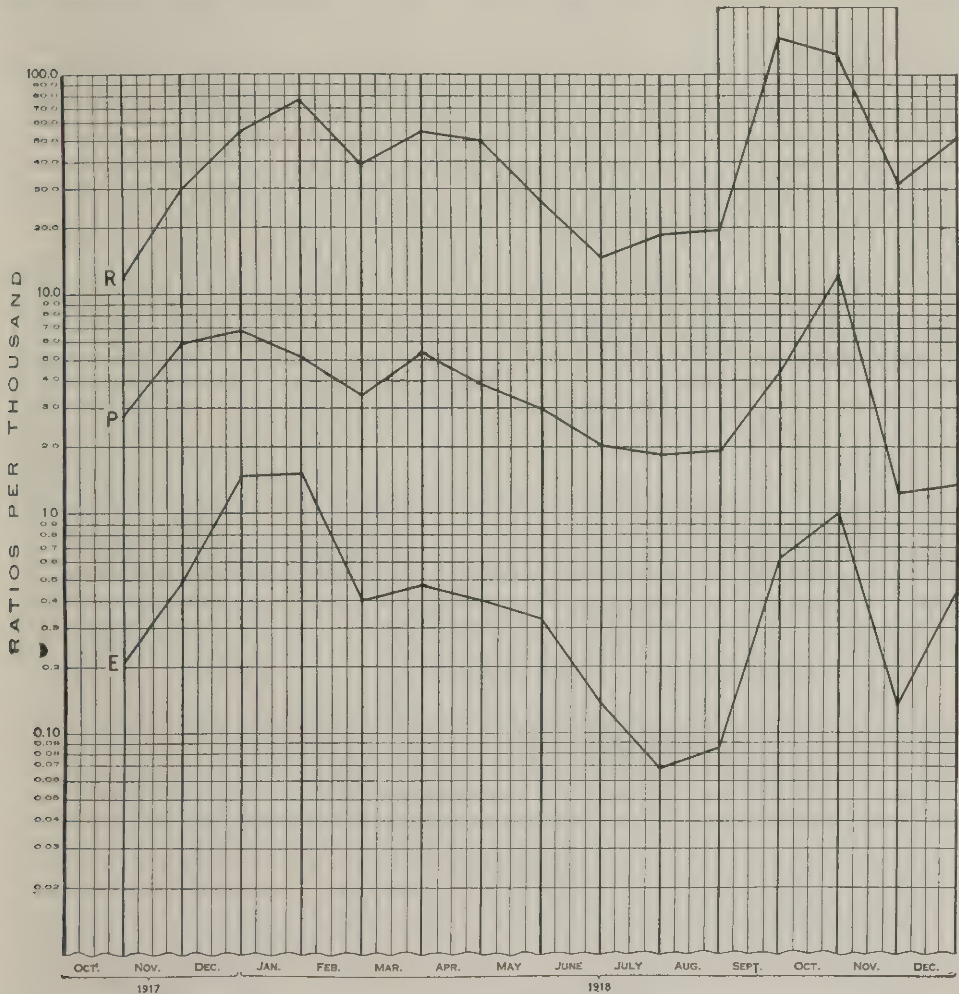


CHART XXXII.—Epidemiological chart for Camp Pike, Ark., in monthly ratios per thousand men.

level of the empyema curve in December and January coincides with a relatively high incidence of influenza in those months, which is not again so marked until this camp participated in the great pandemic in September.

It will be noticed here that during this epidemic the incidence of upper respiratory diseases is greater in September than in October, while the reverse holds for the empyema curve. This was the case in many if not most of the other camps.

A possible explanation of this circumstance is furnished by a comparison of the ratios of deaths per thousand men, from influenza with complications, in September and October.[12] The monthly ratios were 1.98 and 1.25, respectively, i. e., the deaths per 1,000 men were 58 per cent greater in September than in October. It is not probable that the difference in the incidence of empyema was due to variations in the complicating infections giving rise to empyema. It is much more likely that the character of the complications attending the influenza remained substantially the same. But since it takes

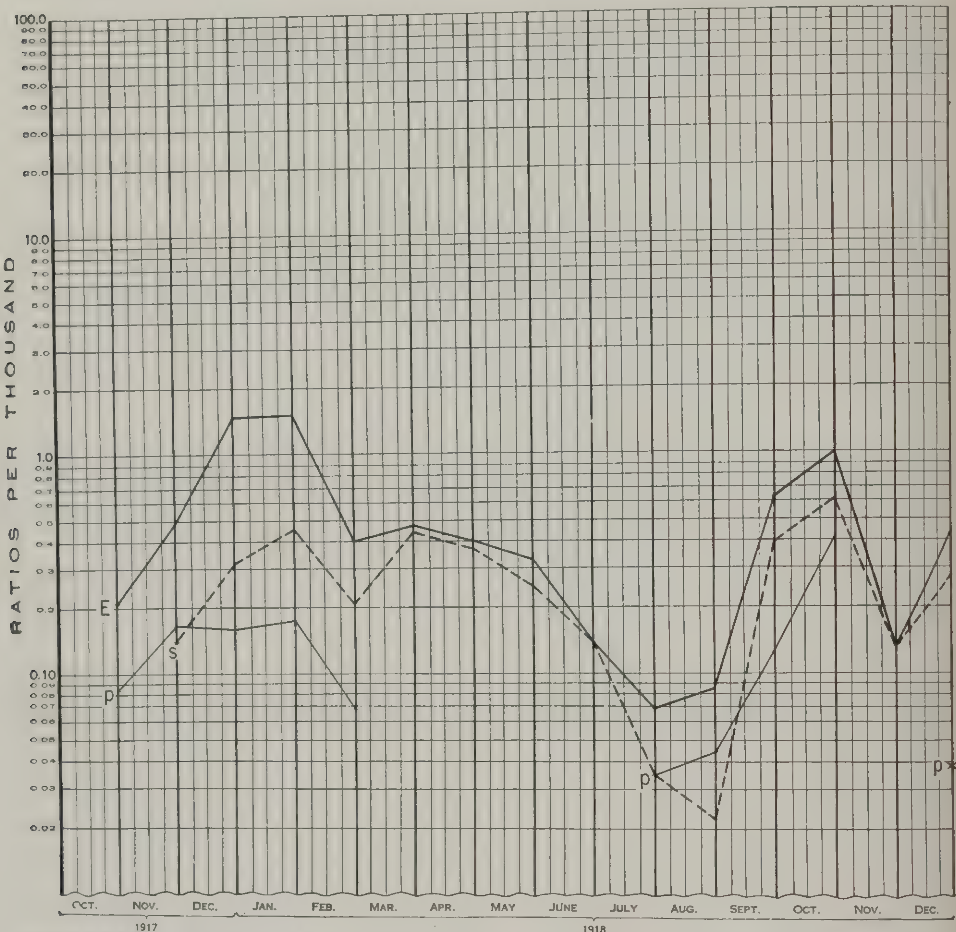


CHART XXXIII.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Pike, Ark.

some time for a pleural infection to reach a stage in its evolution when an empyema would be recognized clinically, it follows that in cases of early death the pleural infection would not be detected, while in those that lived longer it would become manifest as a fully developed empyema. The post-mortem observations on cases which died soon after the onset of influenza have frequently demonstrated the presence of a fibrinopurulent exudate upon the pleural surfaces which would have become empyemata had the cases survived. This delay in the development of empyema would depress the curve of apparent

incidence during a severe epidemic to a degree roughly proportionate to the ratio of early deaths. This same reasoning applies to all periods during which secondary infections of the respiratory organs soon proved fatal. At such times the number of cases in which empyema is established upon clinical evidence falls short of the actual number of serious pleural infections.

At Camp Pike the incidence of upper respiratory diseases never fell below 1 per cent of the men in camp, and corresponding to this is the persistence of empyema throughout the whole period studied.

TABLE 20.[a]—*Epidemiological table for Camp Pike, Ark.*

	Absolute numbers.					Ratios per 1,000 men.					
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	Empyema, mortality percentage.
1917.											
October	5	1	0	2	0	2.76	11.58	0.2095	0	0.0838	20
November	14	7	4	5	1	5.87	29.65	.4829	0.1380	.1625	50
December	47	30	10	5	0	6.74	54.52	1.4665	.3120	.1560	64
1918.											
January	43	18	13	5	0	5.14	76.11	1.4900	.4505	.1732	42
February	12	4	6	5	0	3.37	38.40	.4088	.2045	.0681	33
March	14	5	13	0	0	5.54	55.29	.4611	.4282	.0	36
April	11	0	10	0	0	3.79	49.75	.3993	.3630	.0	0
May	12	2	9	0	0	2.97	26.75	.3289	.2466	.0	17
June	4	0	4	0	0	2.03	14.47	.1373	.1373	.0	0
July	4	0	2	2	0	1.84	18.64	.0678	.0339	.0339	0
August	4	1	1	2	0	1.90	19.65	.0861	.0220	.0440	25
September	34	13	21	7	2	4.37	145.59	.6242	.3856	.1285	38
October	55	14	33	22	0	10.22	122.64	1.0176	.6105	.4070	25
November	5	0	5	0	0	1.22	31.53	.1310	.1310	.0	0
December	11	2	7	1	0	1.32	50.49	.4232	.2690	.0380	18
	275	97	138	56	3	....	....	....	....	....	35.3

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP SHELBY.

Camp Shelby, about 11 miles from Hattiesburg, Miss., a city of 16,000 inhabitants, was used at first for men of the National Guard from Kentucky and Indiana, but in October and November, 1917, there were large additions of drafted men, transferred from other camps.[10] There were but few colored troops until July, 1918.[10] The men were quartered in tents.

There was a sudden and rapid onset of measles in the autumn of 1917.[11] After this the incidence was small, numbering only 521 cases for the whole of 1918. Empyema followed this disease in five instances with one fatality.[12] All five cases occurred between November 19 and December 11, 1917. For those two months the incidence of measles was 1,501 cases. The cases of measles, followed by empyema, closely approximated 1 in 300. The surviving cases were associated, one with pneumococcus, the other three with streptococcus. The bacteriological history of the fatal case is not known.[12]

Four cases of empyema followed mumps, the first in the last week of October, 1917, the last on January 25, 1918.[12] During these four months the admissions for mumps were 1,395.[11] No postscarlatinal cases are recorded.[11]

Of particular interest in Chart XXXIV for Camp Shelby is the abrupt rise in the curve "R" in April, and the slight degree in which this is reflected

in the curve "E," for in many of the camps a rise in "R" at this time of year coincides with a disproportionately greater rise in "E." At Camp Shelby, as elsewhere, the phenominally increased incidence of diseases of the upper respiratory tract was due to an outbreak of influenza, which raised the level of the curve from 13.21 per 1,000 men to a ratio of nearly 117, or an increase of more than 785 per cent. The coincident increase in the empyemata was 44. This is so strikingly different from the experiences in other camps that it must

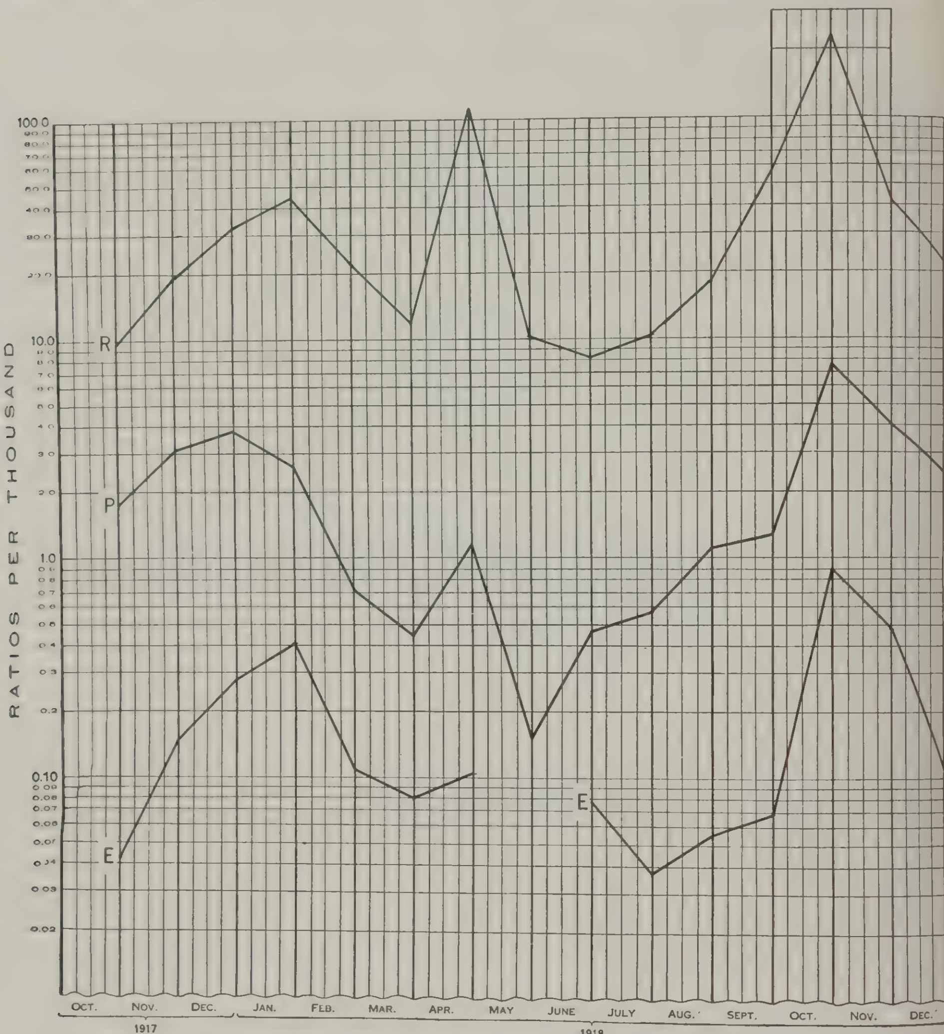


CHART XXXIV.—Epidemiological chart for Camp Shelby, Miss., in monthly ratios per thousand men.

be due to circumstances of great practical importance, particularly as the relations between influenza and empyema in the fall were those common to nearly all camps. The probable explanation is discovered when the attention is directed to two series of related facts concerning the influenza during these two periods. In April the incidence of complications in cases of influenza was only 2.40 per 1,000 men in camp, and there were no deaths whatever from either uncomplicated or complicated influenza. But in October the

incidence of complications was 33.20 and the deaths following influenza (complicated and uncomplicated) 3.65 per 1,000 men.

Turning to the histories of the three cases of empyema in April,[12] it is found that only one is recorded as following influenza and that this was associated with streptococcus viridans in the pleural exudate. The other two cases followed pneumonia and were associated with pneumococcus, Types I and II, respectively.

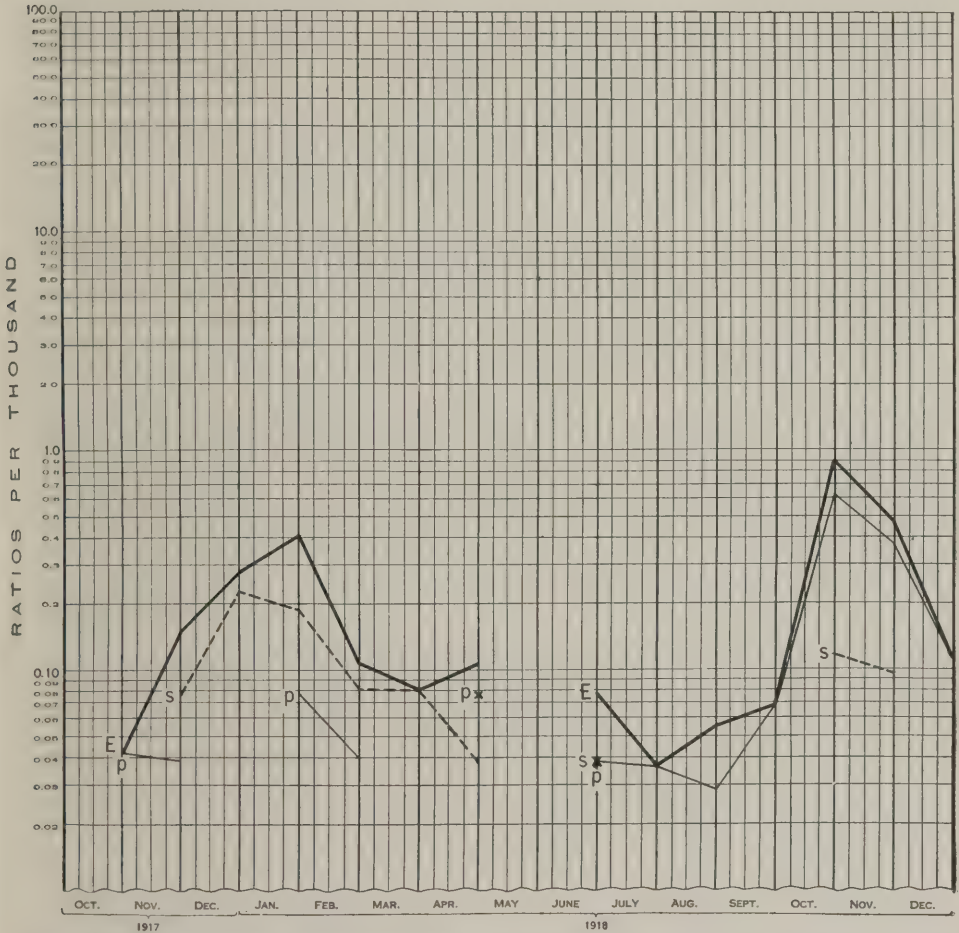


CHART XXXV.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Shelby, Miss.

The foregoing observations, when correlated with the experience in other camps, clearly suggest that influenza is of epidemiological importance in the incidence of empyema in proportion to the prevalence, at the time, of organisms prone to infect the pleura as secondary invaders, and that a pure influenzal infection does not threaten this serous cavity.

It remains to inquire into the nature of the two cases of empyema in June, at the time when diseases of the respiratory tract showed the minimal incidence.

The history of the first case is obscure; the patient was admitted June 8, with a diagnosis of "hyperthyroidism, fever type."[12] It is explicitly stated that the case progressed without pneumonia. Empyema on the right side following a diaphragmatic pleurisy was noted eight days after admission, and one week later a portion of the sixth rib was resected and 720 c. c. of foul-smelling pus were evacuated. This pus apparently contained streptococcus viridans. A little more than five weeks later, a portion of the fourth rib was resected, and 1,000 c. c. of pus were obtained. After this second operation, convalescence began and the case pursued an uneventful course. The patient returned to duty 131 days after admission.

The second case in June was admitted on the 20th with suspected lobar pneumonia.[12] He developed empyema, with thick pus containing Type I pneumococcus, 33 days later, was subjected to thoracotomy, and finally returned to duty 152 days after admission to the hospital.

Table 21.[a]—*Epidemiological table for Camp Shelby, Miss.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	1	0	0	1	0	1.73	9.56	0.0437	0	0.0437	0
November	4	0	2	1	1	2.13	19.25	.1577	.0772	.0386	0
December	7	2	6	0	0	2.81	33.38	.2712	.2321	.0	29
1918.											
January	8	0	5	2	0	1.73	45.35	.3095	.1933	.0775	0
February	3	0	2	1	0	.70	23.37	.1190	.0795	.0398	0
March	2	1	2	0	0	.46	13.21	.0798	.0800	.0	50
April	3	0	1	2	0	1.28	116.95	.1150	.0382	.0763	0
May	0	0	0	0	0	.16	10.87	.0	.0	.0	0
June	2	0	1	1	0	.48	8.13	.0760	.0380	.0380	0
July	1	0	0	1	0	.57	10.71	.0368	.0	.0368	0
August	2	1	0	1	0	1.28	18.00	.0552	.0	.0276	50
September	1	0	0	1	0	1.40	55.84	.0680	.0	.0681	0
October	7	2	1	4	0	7.73	238.07	.8906	.1272	.6370	29
November	5	2	1	4	0	4.00	41.91	.4753	.0950	.3790	40
December	1	0	0	1	0	2.51	24.34	.1261	.0	.1262	0
	47	8	21	20	1	....	....	....	....	....	17

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP BEAUREGARD.

Camp Beauregard, La., about 6 miles from Alexandria, the population of which was 15,000, was at first used for men of the National Guard received from Arkansas, Louisiana, and Mississippi, numbering about 7,000 men.[10] Additions of drafted men from other camps gradually raised the strength to an average of 20,000 in December, 1917. Among these transfers were 9,000 from Camp Pike in November, a time when Camp Pike was heavily infected with measles. The proportion of troops from rural homes was large, presumably nearly 80 per cent of the total number, but negroes never exceeded 1,000 and there was none until after April, 1918.[10] Tents were used to house the men.

Admissions for measles began in October (149 cases).[11] The number increased to 1,546 in November, many cases being imported from Camp Pike;[11] fell to 120 in December; and was negligible through the winter and early

spring of 1918. Postmeasles empyema was reported in nine cases, with two deaths, all occurring between November 17 and December 13, 1917.

Among the 4,574 cases of mumps, none was followed by empyema.[12]

For scarlet fever, there were only three admissions, and none of these developed pleurisy.[11]

The meager data furnished by the special empyema records for the months of the epidemic of influenza fortunately can be supplemented from a pub-

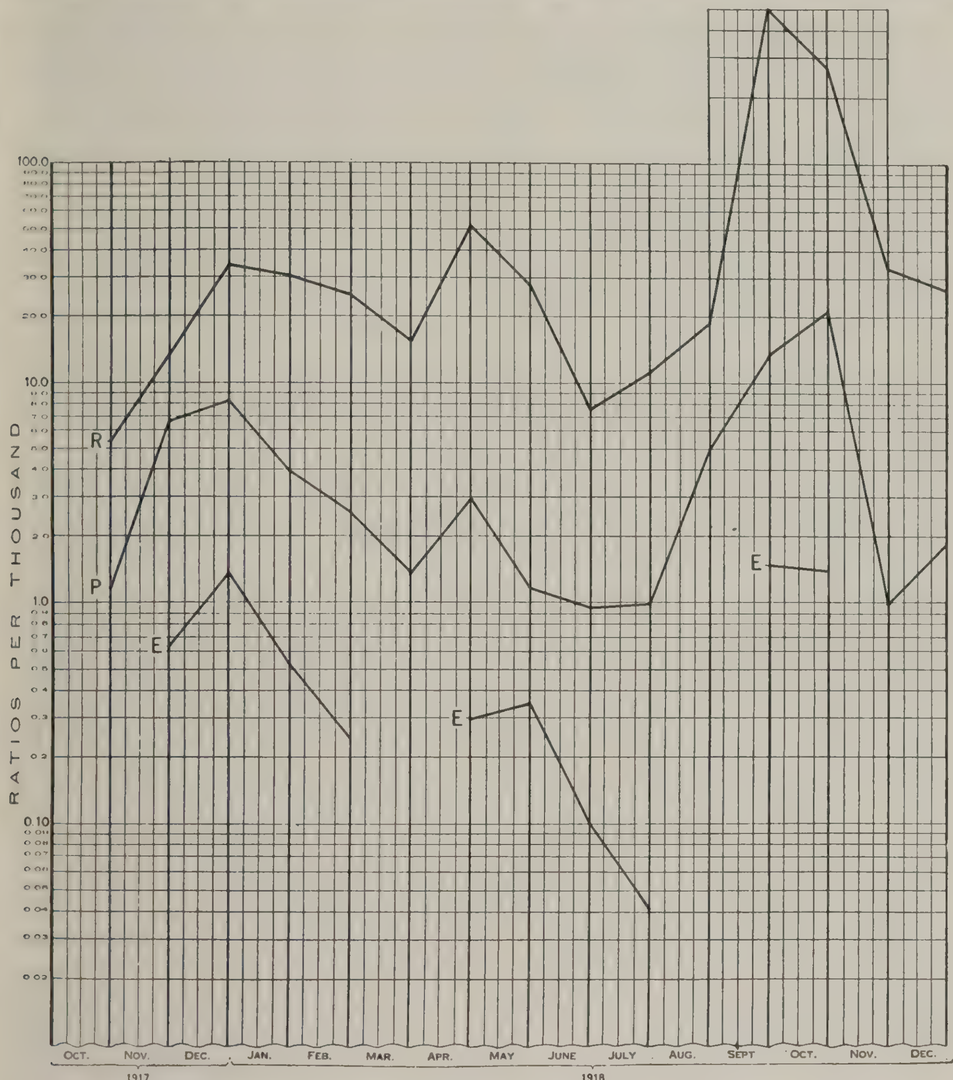


Chart XXXVI.—Epidemiological chart for Camp Beauregard, La., in monthly ratios per thousand men.

lished report by Capt. J. E. McClelland, M. C., who, in 29 cases of empyema, found hemolytic streptococci in three (10 per cent) and pneumococci in 19 (66 per cent).[26] The remaining seven effusions were sterile. Among the pneumococci, 4 were Type I, 6, Type III, 7, Type IV, and 2 were not typed.

At first glance, Chart XXXVI for Camp Beauregard, with particular reference to empyema, appears to be an erratic distribution of unrelated lines.

In the light of the studies on the data from other camps, the empyema curve is interrupted where it should be continuous, reappears where it should be absent, and, as shown on Chart XXXVII, is associated everywhere with the wrong dominance in bacterial species. It is just such phenomena that particularly invite study and are likely to prove more than ordinarily instructive.

It is evident that during the two preceding months all the respiratory diseases were on the down grade, tending toward a point where empyema

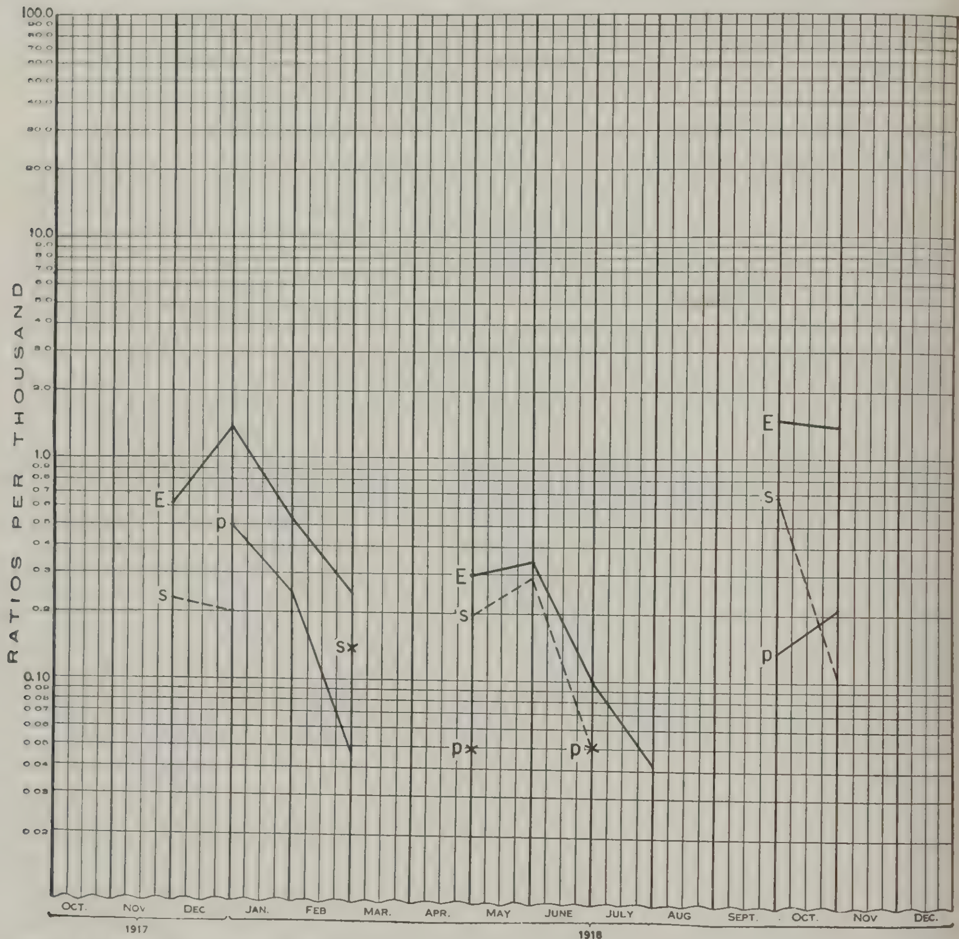


CHART XXXVII.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Beauregard, La.

would entirely disappear, and that during these preceding months the character of the pleural infections was of the less serious type, when abruptly something happened in April which for a time changed the course of events. As far as available data can throw light on the nature of this reversing influence, it was an outbreak of influenza with an unusually high proportion of complications, these being about one-seventh of the whole number of cases. Now, it is evident from Chart XXXVII that, at least as far as empyemata are concerned, the streptococcus entered here as a potent factor in secondary infections for the first time in this camp. Furthermore, it continued to so act in September, and was still prevalent in October.

It would be of very great interest could this comparatively late entrance of the streptococcus as a complicating factor be explained by some coincident or immediately preceding event in the history of the camp. The only suggestion offered by the special empyema records lies in the earlier sporadic appearance of this organism in a few cases of empyema. Possibly the advent of influenza among the troops with a slight increase in the strength of the camp, leading to closer contacts among the men, may have been the determining factors leading to a dissemination of the streptococcus. Possibly the weather may have made such contacts particularly close in March and early April. Questions such as these must be left unanswered for lack of data; but, though the explanation is not forthcoming, the sudden, coincident appearance of influenza, empyema and the streptococcus, at a time when previous conditions would have warranted a favorable forecast, is very striking. A similar occurrence took place in September, equally abrupt and also transient.

TABLE 22.[a]—*Epidemiological table of Camp Beauregard, La.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group	Pneumococcus group.	
1917.											
October	0	0	0	0	0	1.14	5.42	0	0	0	0
November	11	4	4	0	0	6.77	13.48	0.6264	0.2280	0	36
December	27	4	4	10	0	8.29	33.87	1.3508	.2000	0.5000	15
1918.											
January	13	5	0	6	0	3.93	30.35	.5272	.0	.2440	38
February	5	1	3	1	0	2.50	25.07	.2399	.1380	.0460	20
March	0	0	0	0	0	1.35	15.11	.0	.0	.0	0
April	6	3	4	1	0	2.95	51.11	.2966	.1975	.0494	50
May	7	3	6	0	0	1.16	27.55	.3377	.2895	.0	43
June	2	0	1	1	0	.95	7.43	.1005	.0503	.0503	0
July	1	1	0	0	0	.99	10.11	.0412	.0	.0	100
August	0	0	0	0	0	5.00	18.75	.0	.0	.0	0
September	11	2	5	1	0	13.39	500.41	1.4628	.6650	.1330	18
October	13	5	6	1	0	21.44	271.64	1.3753	.1057	.2114	38
November	0	0	0	0	0	.99	32.81	.0	.0	.0	0
December	0	0	0	0	0	1.79	26.27	.0	.0	.0	0
	96	28	33	21	0	....	....	....	....	....	29.2

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP LOGAN.

Camp Logan, Tex., in the immediate outskirts of Houston, a city of approximately 110,000 inhabitants, was first occupied by 20,000 men of the National Guard of Illinois, arriving in September, 1917.[10] These were augmented by men transferred from other camps during the next two months. Colored troops were present from the beginning, but in very fluctuating numbers, and never much over 2,500. The men were quartered in tents.[10]

Two cases of empyema followed measles, one in December, 1917, and one in February, 1918.[12] The admissions for measles in those months were 195 and 197, respectively.[11] In neither case is there any record of bacteriological findings.

No cases followed either mumps or scarlet fever, the admissions for which were 471 and 37, respectively.[11]

The incidence of respiratory diseases appears to have been governed by a continual presence of influenza, which showed almost as high a rate in April (86.21) as in October (88.29), although the climax was in September (200.86).[11]

The curve of incidence for empyema shows, in general, a closer correspondence to that of upper respiratory diseases than to that of the pneumonias, but displays wider fluctuations than either. This suggests an influence affecting the development of empyema, but not reflected in the incidence

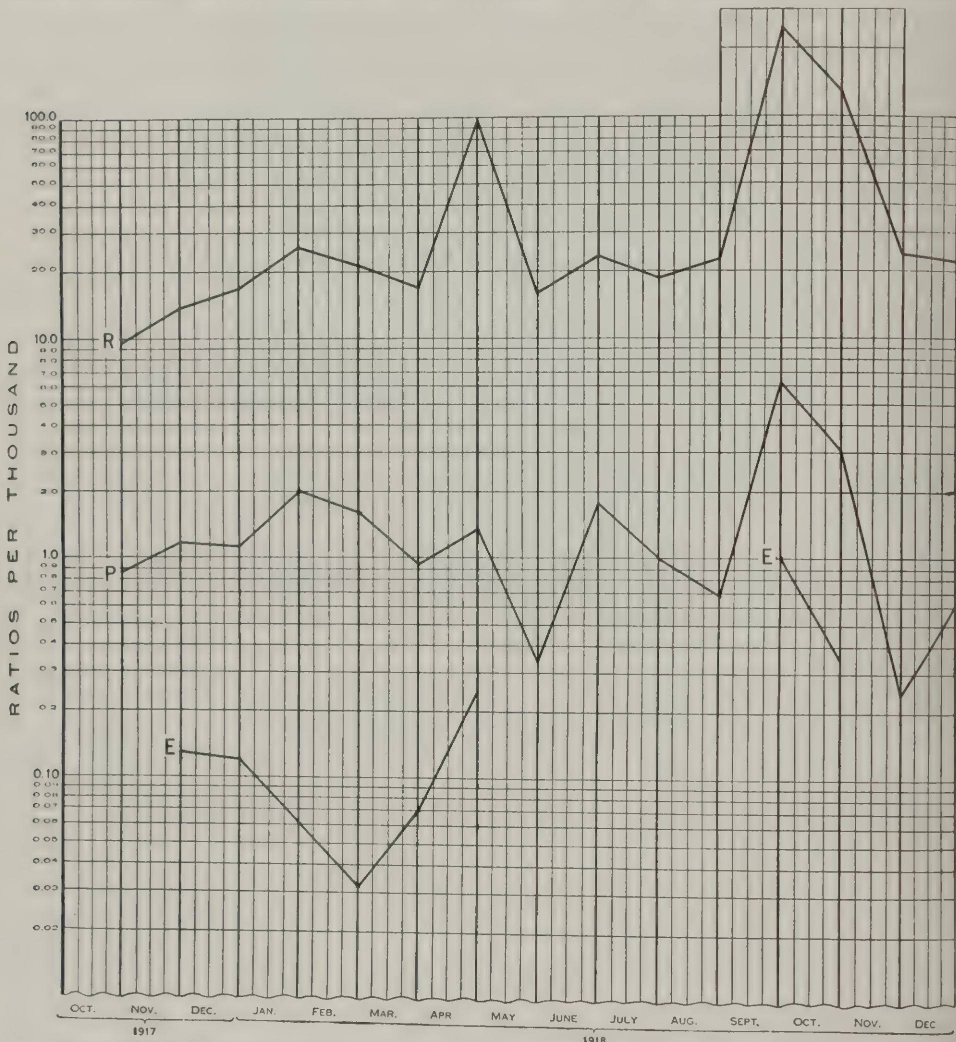


CHART XXXVIII.—Epidemiological chart for Camp Logan, Tex., in monthly ratios per thousand men.

of primary respiratory diseases. This influence may well be the prevalence or rarity in camp of the organisms commonly found in pleural exudates. These may fail to occasion infection of the more remote respiratory organs unless some intercurrent circumstance creates conditions favoring such a development. When this occurs the resulting empyema may appear out of proportion to this favoring factor.

The high incidence of respiratory diseases in May, June, July, and August, 1918, when empyema failed to occur, was due to an unusual number of uncomplicated cases of influenza without any fatalities.

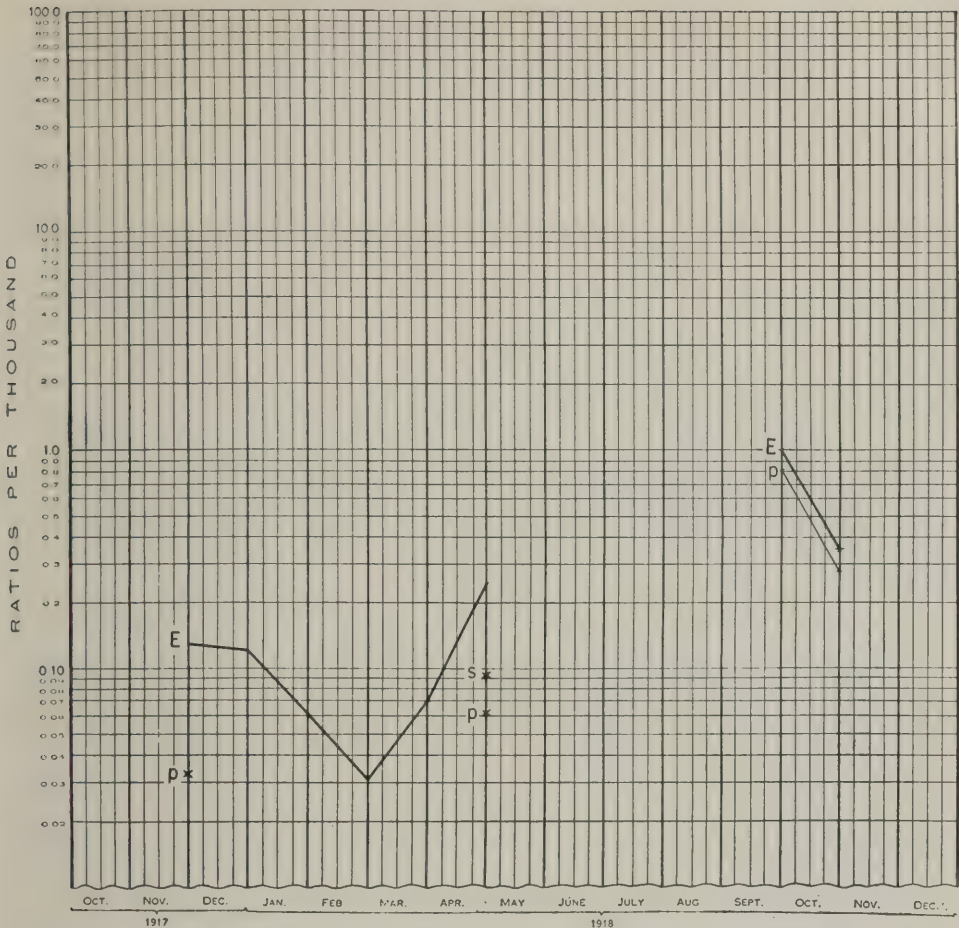


CHART XXXIX.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Logan, Tex.

TABLE 23.[a]—*Epidemiological table for Camp Logan, Tex.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	0	0	0	0	0	0.85	9.53	0.0	0.0	0.0	0
November	4	1	0	1	0	1.16	13.80	.1282	0	.0321	25
December	4	0	0	0	0	1.12	16.90	.1199	0	.0	0
1918.											
January	2	1	0	0	0	2.04	25.89	.0613	0	.0	50
February	1	0	0	0	0	1.59	21.14	.0314	0	.0	0
March	2	0	0	0	0	.94	16.85	.0690	0	.0	0
April	8	3	3	2	1	1.33	97.58	.2476	0.0918	.0612	38
May	0	0	0	0	0	.33	15.85	.0	.0	.0	0
June	0	0	0	0	0	1.74	23.23	.0	.0	.0	0
July	0	0	0	0	0	1.01	18.80	.0	.0	.0	0
August	0	0	0	0	0	.66	22.54	.0	.0	.0	0
September	10	1	0	7	1	6.20	249.12	1.0215	.0	.8160	10
October	5	1	0	4	0	3.06	125.60	.3470	.0	.2773	20
November	0	0	0	0	0	.24	23.57	.0	.0	.0	0
December	0	0	0	0	0	.60	22.03	.0	.0	.0	0
	36	7	3	14	2	....	....	....	....	....	19.4

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP BOWIE.

Camp Bowie, Tex., located in the suburbs of Fort Worth, a city of 100,000 inhabitants, served at first for men of the National Guard from Texas and Oklahoma, who began to arrive the latter part of August, 1917, and by the end of September numbered approximately 17,000.[10] In October drafted troops arrived from other camps, notably Camp Travis, bringing the strength up to slightly over 30,000.[10] The 36th Division moved overseas about July, 1918,

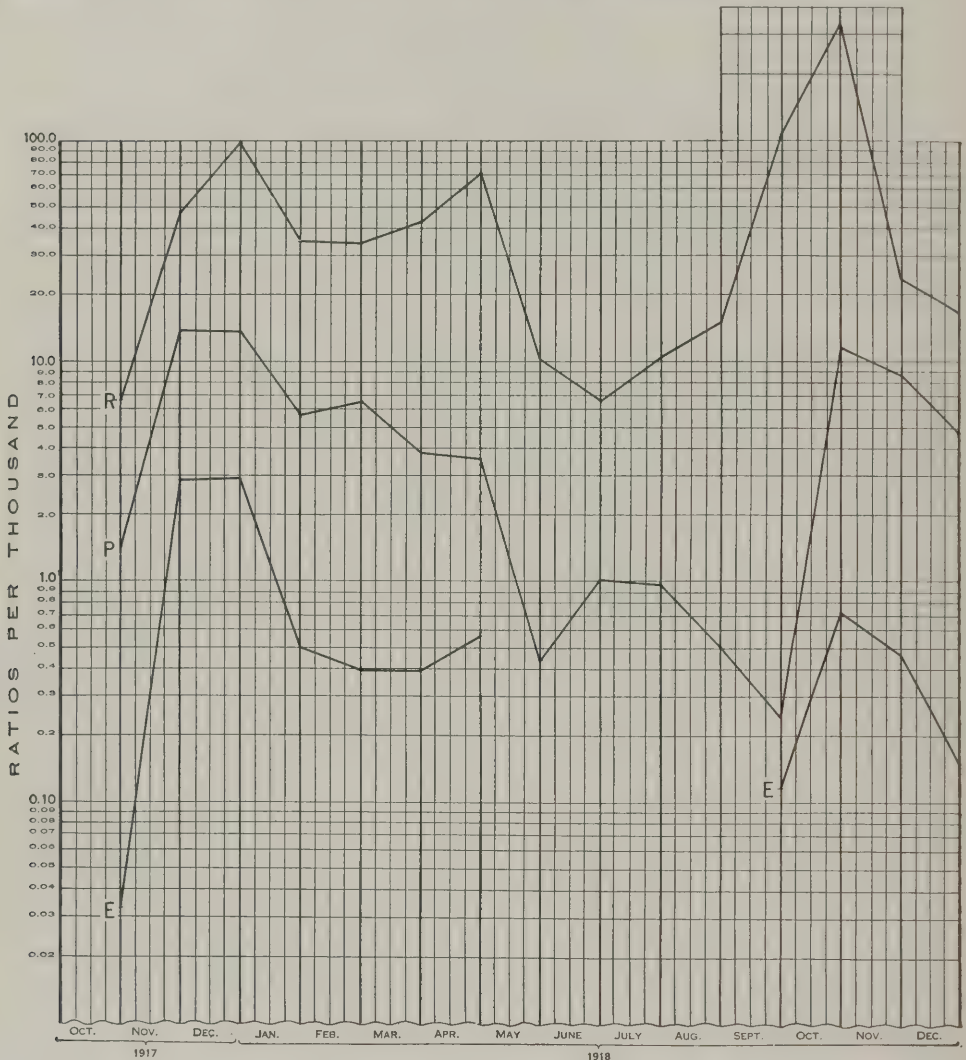


CHART XL.—Epidemiological chart for Camp Bowie, Tex., in monthly ratios per thousand men.

after which the camp was used for training replacement Infantry, men coming from such widely separated localities as California and Louisiana.[10] There were no colored troops until September, 1918, and the average number in any one month never reached 3,000. The troops were quartered in tents.

An epidemic of measles visited the camp in the autumn of 1917.[11] As early as October, 293 cases were admitted for this disease. For November

the number rose to 3,163, fell in December to 178, and thereafter became negligible. All the postmeasles empyema occurred during this initial period of high incidence of the primary disease and amounted to 55 cases, including 38 that died.[12] The first case occurred November 4 and proved fatal, having developed a bilateral pneumonia. The incidence of these empyemata was 1.6 per cent of the total measles; the mortality among the postmeasles cases was 69 per cent. Concerning the bacteriology of the pleural exudates in these particular cases the data are very deficient. Among the 17 surviving cases,

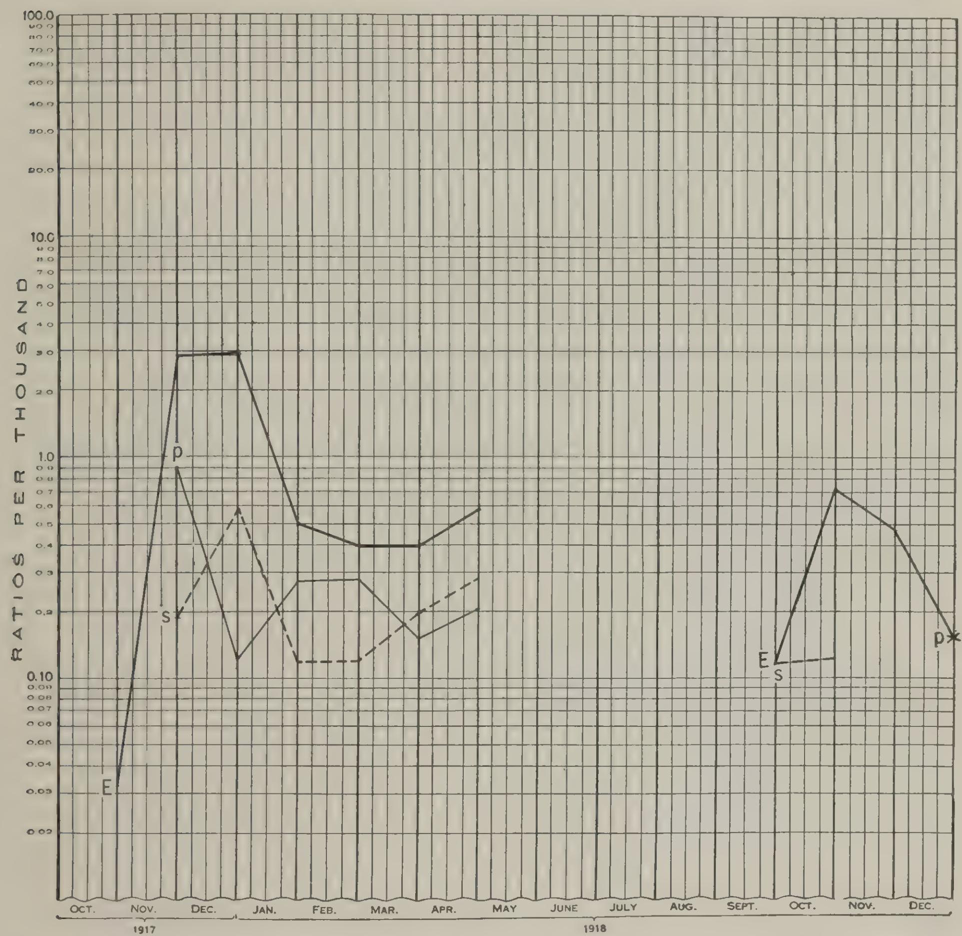


CHART XLI.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Bowie, Tex.

4 yielded pneumococci, 1, streptococci, 1, staphylococci, but there are no available data for the remaining 11. Information concerning 38 fatal cases is equally disappointing—6, pneumococci, 6, streptococci, and 26, unrecorded.[12]

There were only 2 cases of empyema preceded by mumps, although the admissions for the latter were 5,317.[11] Both of these cases recovered; one was associated with pneumococcus, the other was without data concerning the organism present. No postscarlatinal cases were reported, and there were altogether only seven admissions for scarlet fever.[11]

The bacteriological findings in the empyema cases at Camp Bowie, limited to those contained in the special empyema records, are given in Table 24. It will be noted that the pneumococcus is the predominant organism. For the period which extended to about March 22, 1918, this relative preponderance of pneumococci is substantiated by the reply to the questionnaire of February 21.[9] Of 146 cases a pneumococcus was found alone in 100 (69 per cent), associated with streptococcus in 28, streptococcus alone in 17, and staphylococcus in 1. Taking all cases in which the streptococcus was present, the proportion was 31 per cent.

For the later period of high incidence of empyema, light is thrown by data in an article published in July, 1919,[27] on the relative frequency with which the pleural exudate yielded pneumococci or streptococci. It was shown that there were of the pneumococcus alone, 32; pneumococcus with hemolytic streptococcus, 30; hemolytic streptococcus alone, 3.

Chart XL shows a marked likeness between the curves "R" and "E," with a typical interruption of the latter when "R" drops to the level of 1 per cent. The rise in April is coincident with the familiar increased incidence of influenza at that time. But the upward trend of "E" at this time is not exaggerated, and in Chart XLI the curves "s" and "p" show that, in so far as the bacteriological data are available, neither the pneumococcus nor the streptococcus was greatly predominant at this time. Taken in connection with the information garnered from other camps as well as from Camp Bowie it would appear that the incidence of empyema depends upon two factors: The prevalence at the time of organisms capable of inducing empyema, and the occurrence of infections favoring the migration of these organisms from the upper respiratory tract into the lungs.

TABLE 24.[a]—*Epidemiological table for Camp Bowie, Tex.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	1	0	0	0	0	1.42	6.68	0.0324	0	0	0
November	76	45	5	24	1	13.81	47.64	2.8718	0.1890	0.9080	59
December	64	12	14	9	0	13.63	98.48	2.9343	.5804	.1201	19
1918.											
January	13	4	3	7	0	5.74	35.13	.5039	.1164	.2710	31
February	10	1	3	8	0	6.53	33.81	.3940	.1182	.2768	10
March	10	1	5	4	0	3.83	42.83	.3925	.1963	.1510	10
April	14	2	7	5	1	3.55	71.68	.5702	.2844	.2040	14
May	0	0	0	0	0	.44	10.20	.0	.0	.0	0
June	0	0	0	0	0	1.02	6.57	.0	.0	.0	0
July	0	0	0	0	0	.97	10.36	.0	.0	.0	0
August	0	0	0	0	0	.51	15.08	.0	.0	.0	0
September	1	1	1	0	0	.24	106.18	.1148	.1148	.0	100
October	12	2	2	0	0	11.67	336.39	.7260	.1209	.0	17
November	4	1	0	0	0	8.68	23.74	.4662	.0	.0	25
December	1	0	0	1	0	4.72	16.66	.1506	.0	.1506	0
	206	69	40	58	2	....	....	....	....	....	33.5

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP TRAVIS.

Camp Travis, Tex., bordering upon and partly within the city limits of San Antonio, which has a population of about 100,000, was a National Army cantonment.[10] Drafted men came here from Texas and Oklahoma. They were mostly from rural districts, the territory furnishing them being, as a whole, about 23 per cent urban.[10] Starting early in September, the strength of the

camp rapidly increased, and by the end of that month reached 18,000.[10] In October the average strength was 26,000 and in November, 33,000. In this month nearly 8,000 of the men were colored, and until the end of 1918 there was always a large contingent of negroes in the command.[10] The 90th Division moved overseas about June, 1918, but accessions maintained the previous strength of the camp.[10] The quarters were frame barrack buildings.[10]

As in most of the camps of this general character, the admissions for the usual infectious diseases were high, particularly during the early months.[11]

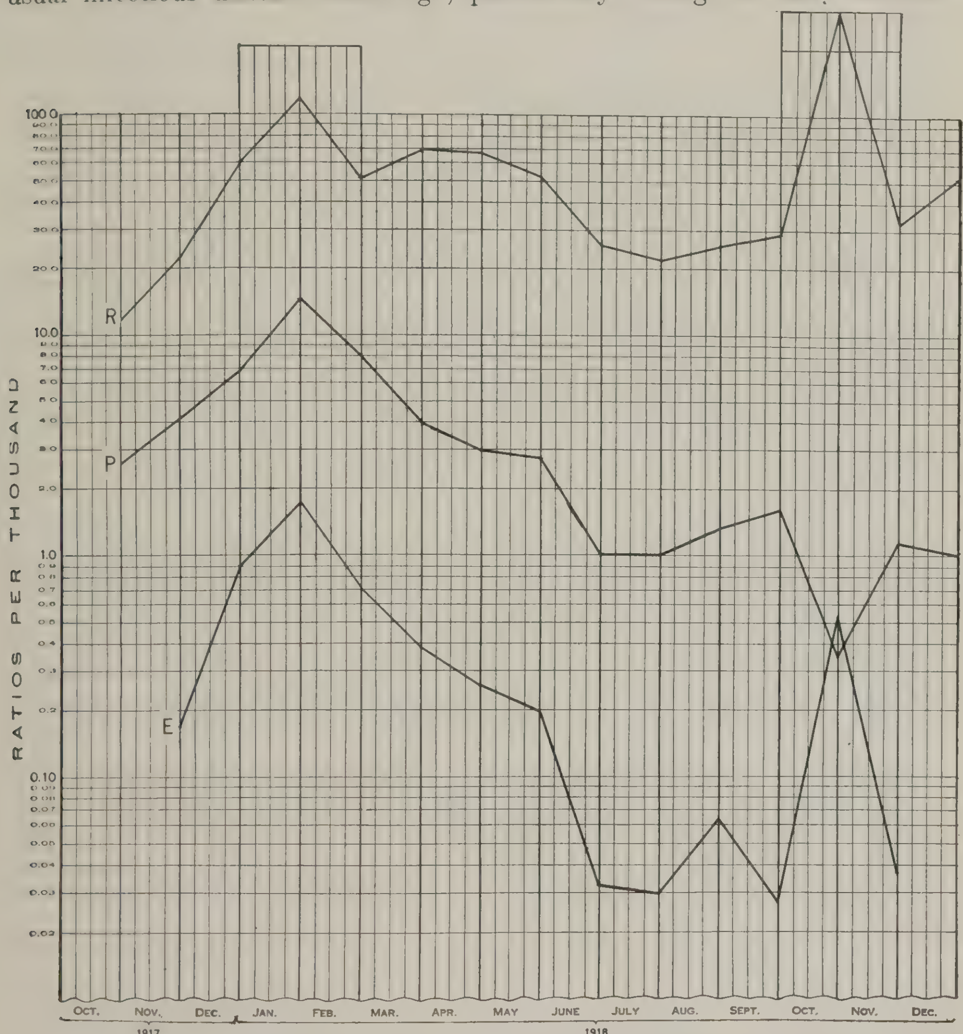


CHART XLII.—Epidemiological chart for Camp Travis, Tex., in monthly ratios per thousand men.

The cases of measles, after small beginnings in October, abruptly rose to 2,671 in November, were 1,435 in December, and then fell to 46 in January, after which there were only 545 during the remainder of 1918.[11] Corresponding to these figures were 14 cases of postmeasles empyema between November 24 and December 14. Two of these, one associated with streptococcus, proved fatal. In the other, the pneumococcus was found in the pleural exudate.[12]

Only one case of empyema followed mumps, notwithstanding a record of 8,277 admissions for this disease.[11] There were no postscarlatinal cases.[12]

The special empyema records give bacteriological data for 107 out of the 158 cases reported. The pneumococcus was found in 63 per cent of these, and appears to have been the predominating organism associated with empyema at Camp Travis. Possibly the low mortality, 17 per cent, is related to this circumstance. There are no available data other than the special empyema records concerning the bacteriology in the earlier months, but the findings in 49 pleuritic effusions and empyemata during the epidemic of influenza were

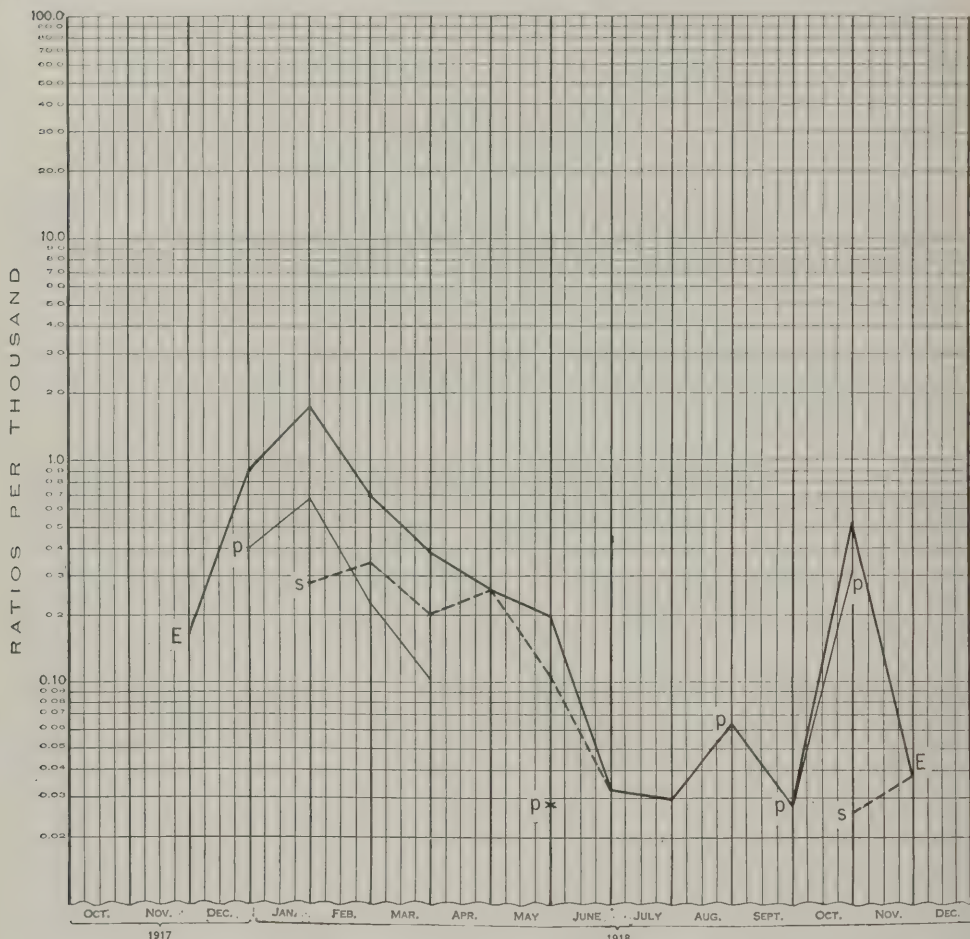


CHART XLIII.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Travis, Tex.

published by the chief of the laboratory service.[28] Twenty-four of these gave negative cultures. In the 25 giving positive findings the results were pneumococcus alone, 13; pneumococcus with influenza bacillus, 5; influenza bacillus alone, 1; Friedländer bacillus, 1; streptococcus alone, 3; and streptococcus with pneumococcus, 2. The cases associated with the pneumococcus were, therefore, about four times as numerous as those associated with the streptococcus. It is of interest to note that the pneumococcus predominated in other complications during this epidemic. In 16 cases of meningitis the article referred to reports that a pneumococcus was found in all, without a single case in which streptococci were present.

Cases of empyema were continuously present at Camp Travis during the period of low incidence of upper respiratory diseases, but it will be noted that these never fell in number to 1 per cent of the command.[12]

In October, 1918, the cases of empyema were more numerous than those of lobar and bronchopneumonia combined. This illustrated the difficulty of untangling the confusing physical signs presented by the cases at this time.[12]

TABLE 25.[a]—*Epidemiological table for Camp Travis, Tex.*

	Absolute numbers.					Ratios per 1,000 men.					
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	Empyema, mortality percentage.
1917.											
October	0	0	0	0	0	2.59	11.59	0	0	0	0
November	6	0	0	0	0	4.14	22.07	0.1786	0	0	0
December	30	6	1	13	0	6.79	60.32	.9157	0	0.3960	20
1918.											
January	52	10	9	21	0	14.62	128.01	1.6977	0.2839	.6850	19
February	19	5	9	6	0	8.05	51.38	.7032	.3333	.2222	26
March	11	2	6	3	0	3.92	68.41	.3781	.2060	.1030	18
April	7	1	7	0	0	3.01	66.35	.2568	.2564	.0	14
May	7	0	4	1	0	2.74	52.86	.1962	.1120	.0280	0
June	1	1	1	0	0	1.04	25.45	.0335	.0335	.0	100
July	1	0	0	0	0	1.02	21.96	.0294	.0	.0	0
August	2	0	0	2	0	1.31	24.93	.0642	.0	.0642	0
September	1	0	0	1	0	1.64	28.59	.0271	.0	.0271	0
October	20	2	1	20	1	.36	293.30	.5306	.0265	.3184	10
November	1	0	1	0	0	1.11	32.70	.0366	.0366	.0	0
December	0	0	0	0	0	1.04	52.96	.0	.0	.0	0
	158	27	39	67	1	....	....	....	....	....	17.1

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP CODY.

Camp Cody, N. Mex., about 3 miles from Deming, a town of approximately 5,000 inhabitants, was first occupied by men of the National Guard from Minnesota, Iowa, Nebraska, North Dakota, and South Dakota.[10] They were not wholly without experience as soldiers but were from regions in which there were few large cities. The arrivals during September, 1917, were about 12,000.[10] In October over 10,000 men came from other camps.[10] These were drafted men and their arrival disturbed the uniformity in origin of the command. The average strength in October was about 22,000 men and ranged between this and 28,000 until the departure of the 34th Division, about August, 1918, when the strength fell to nearly 4,000 and was not again increased beyond about 9,000.[10] At no time were there more than a very few colored troops. The men were quartered in tents.

Measles was not prevalent at Camp Cody. The total number of admissions for the 15 months beginning October 1, 1917, was 550.[11] The highest incidence was in the fall of 1917, when there were 164 in November with 11 with pneumonia, and, in December 169, of which 14 were complicated with pneumonia. During this period there were 8 cases of postmeasles empyema, 3 dying.[12] Of the total measles (333) this would be 2.4 per cent developing emypema, but 34 per cent of the measles-pneumonias. In four of the cases, streptococci were found in the pleural exudate; in one the pneumococcus; and in the remaining three there are no bacteriological data.

No cases of empyema followed either mumps or scarlet fever.[11]

In Table 26, based on the special empyema records,[12] the proportion of streptococcus empyemas is 60 per cent. In the reply to the questionnaire of

February 21, 1918, it is 62.5 per cent.[9] The two reports are in substantial harmony and do not indicate a considerable preponderance of streptococcus infections.

The relation of the incidence of empyema to that of upper respiratory diseases as shown on Chart XLIV is of interest. When the latter fell to approximately 1 per cent in May, there was no empyema reported. In June, however,

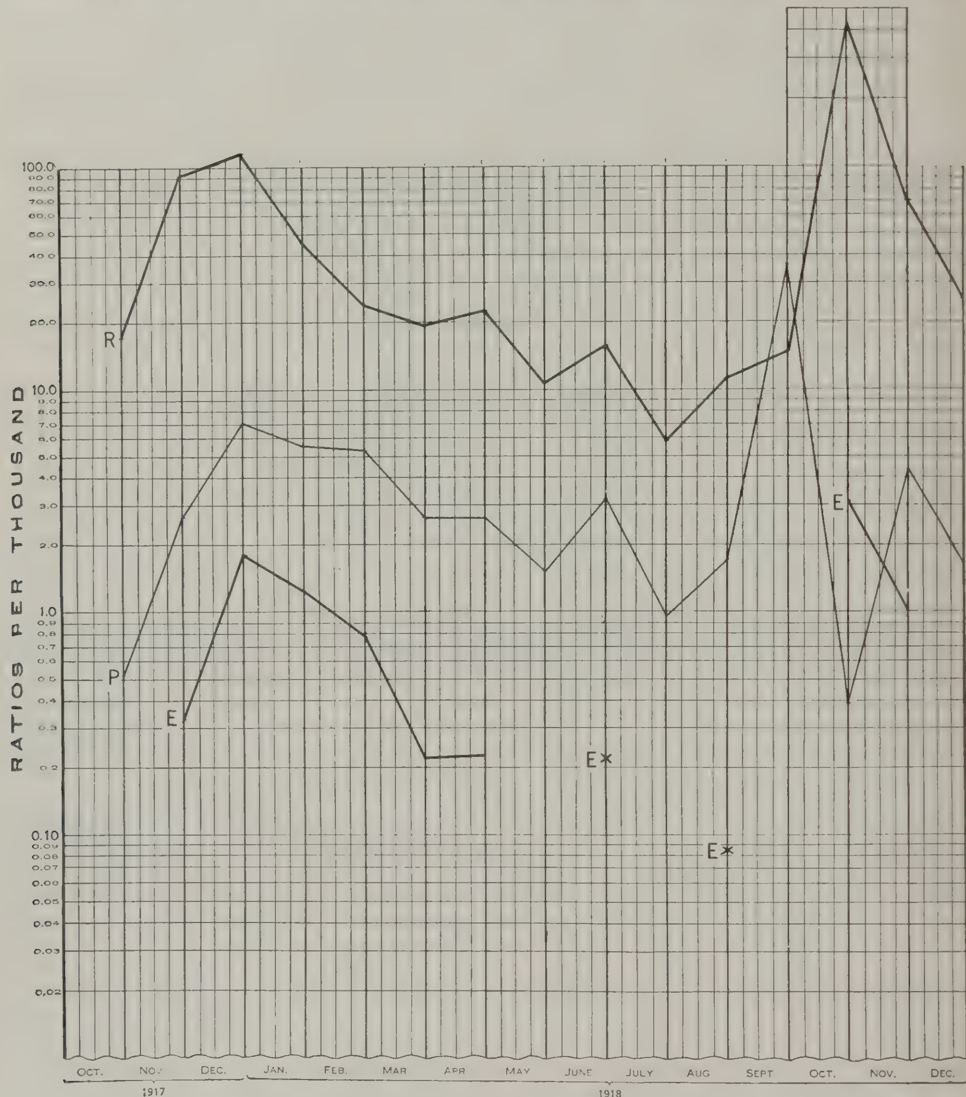


CHART XLIV.—Epidemiological chart for Camp Cody, N. Mex., in monthly ratios per thousand men.

a month when empyema is usually absent, the respiratory diseases rose and three cases of empyema appear, two of which were associated with streptococci. In the following month the conditions noted in May are repeated, and in August, again an unusual month for empyema, these reappear with the rise in diseases of the upper respiratory tract. Had there been one or two cases of empyema in September this series of coincidences would have been unbroken from January to November, inclusive.

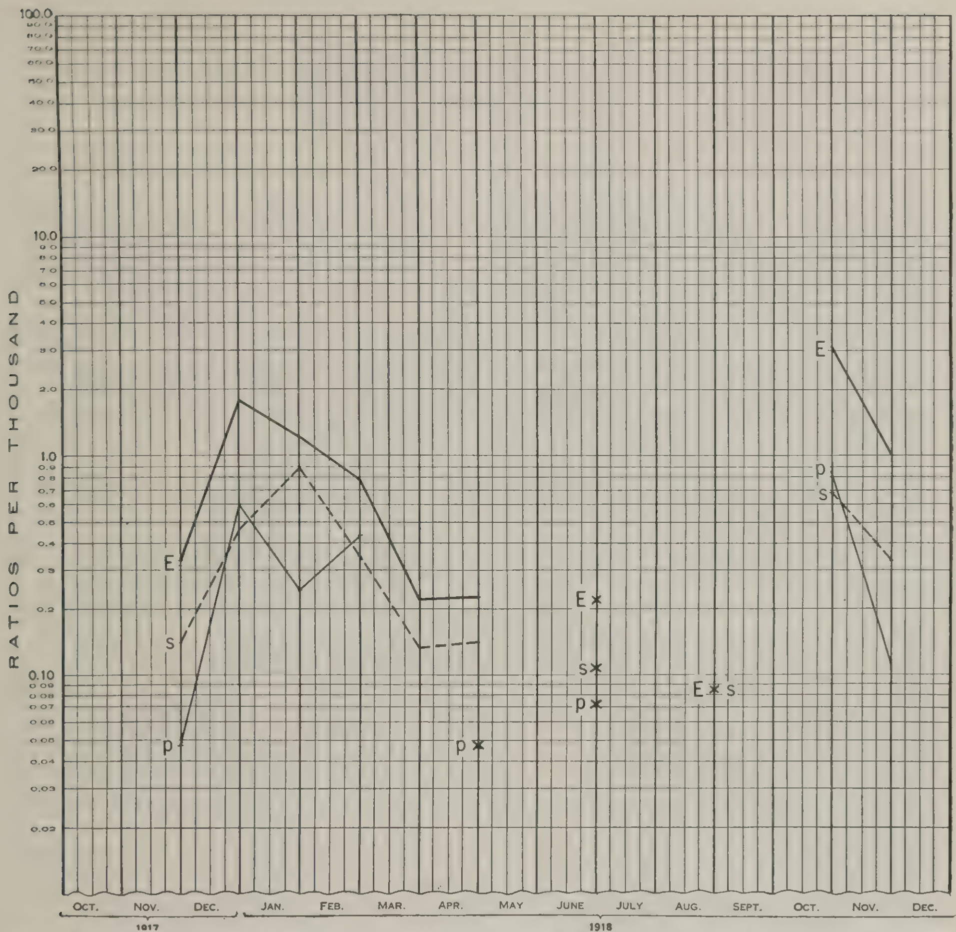


CHART XLV.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Cody, N. Mex.

TABLE 26.[a]—*Epidemiological table for Camp Cody, N. Mex.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	0	0	0	0	0	0.52	17.01	0	0	0	0
November	7	1	3	1	0	2.66	92.99	0.3269	0.1401	0.0468	14
December	39	12	10	13	0	7.07	114.96	1.7852	.4575	.5970	31
1918.											
January	30	10	22	6	0	5.62	46.06	1.2146	.8907	.2430	33
February	18	2	8	10	0	5.39	23.69	.7739	.3440	.4290	11
March	5	2	3	0	0	2.65	19.62	.2182	.1310	.0	40
April	5	1	3	1	0	2.63	22.32	.2241	.1407	.0469	20
May	0	0	0	0	0	1.51	10.84	.0	.0	.0	0
June	6	0	3	2	0	3.19	15.82	.2164	.1082	.0721	0
July	0	0	0	0	0	.96	5.82	.0	.0	.0	0
August	1	0	1	0	0	1.69	11.22	.0858	.0858	.0	0
September	0	0	0	0	0	36.27	14.95	.0	.0	.0	0
October	17	3	4	5	1	.39	431.70	3.0965	.6810	.8510	18
November	9	1	3	1	0	4.36	70.40	.9978	.3330	.1110	11
December	0	0	0	0	0	1.65	25.09	.0	.0	.0	0
	137	31	60	40	1						22.6

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP FREMONT.

Camp Fremont, Calif., near Palo Alto, the population of which was about 5,000, served for the organization of the 8th Division of the Regular Army, beginning in January, 1918, when the average strength in enlisted men was 6,744.[10] This strength gradually increased to June, when it was 23,000. The number of colored troops was negligible.[10]

The admissions for measles and mumps were moderate in number, being 474 and 443, respectively, for the year.[11] Two cases of postmeasles empyema are recorded in February, 1918, when the total admissions for measles was 24.[12]

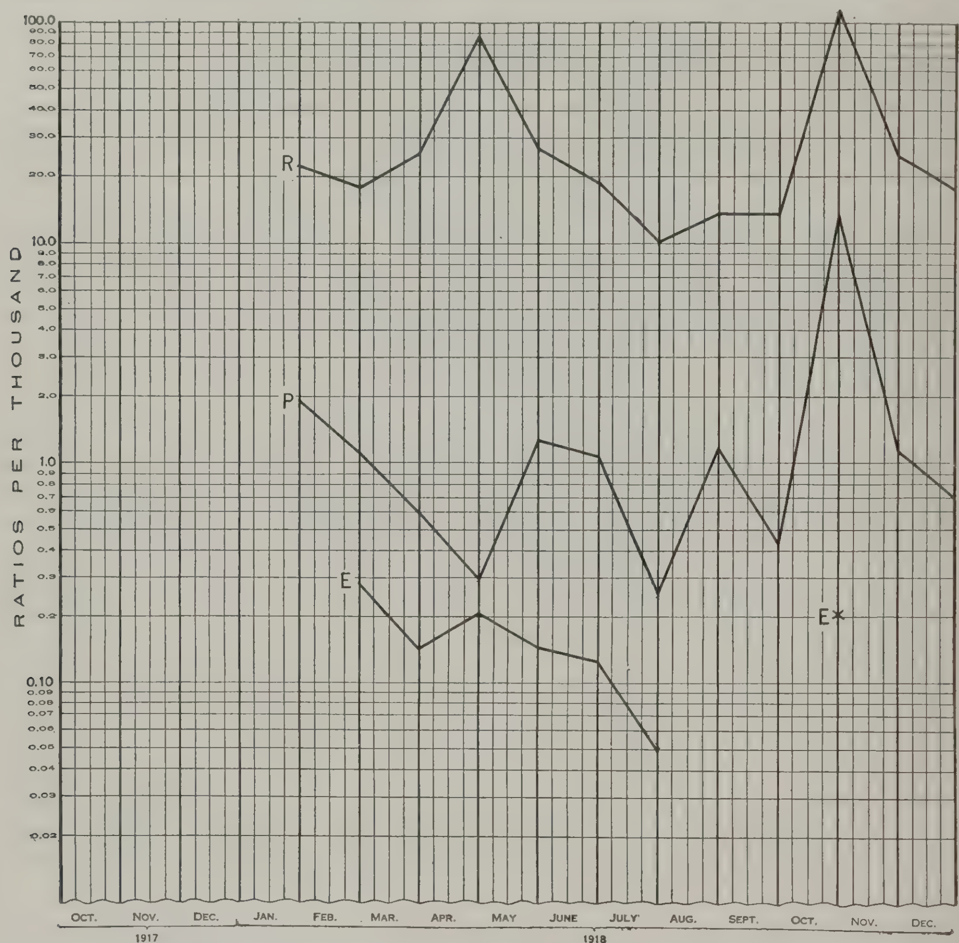


Chart XLVI.—Epidemiological chart for Camp Fremont, Calif., in monthly ratios per thousand men.

Both cases were associated with streptococcus, and both recovered. No empyema developed in cases of mumps, or in the cases of scarlet fever for which there was a total of 14 admissions.[11]

The total number of empyema cases at Camp Fremont was so small and their distribution was on the whole so nearly uniform, that the data derived from them offer little opportunity for deductions of epidemiological value. One feature of interest shown on Chart XLVI is the independence of the empyema in respect to pneumonia, and the comparative faithfulness with which it conforms to the curve for diseases of the upper respiratory tract, notwithstanding the inexplicable exception in March.

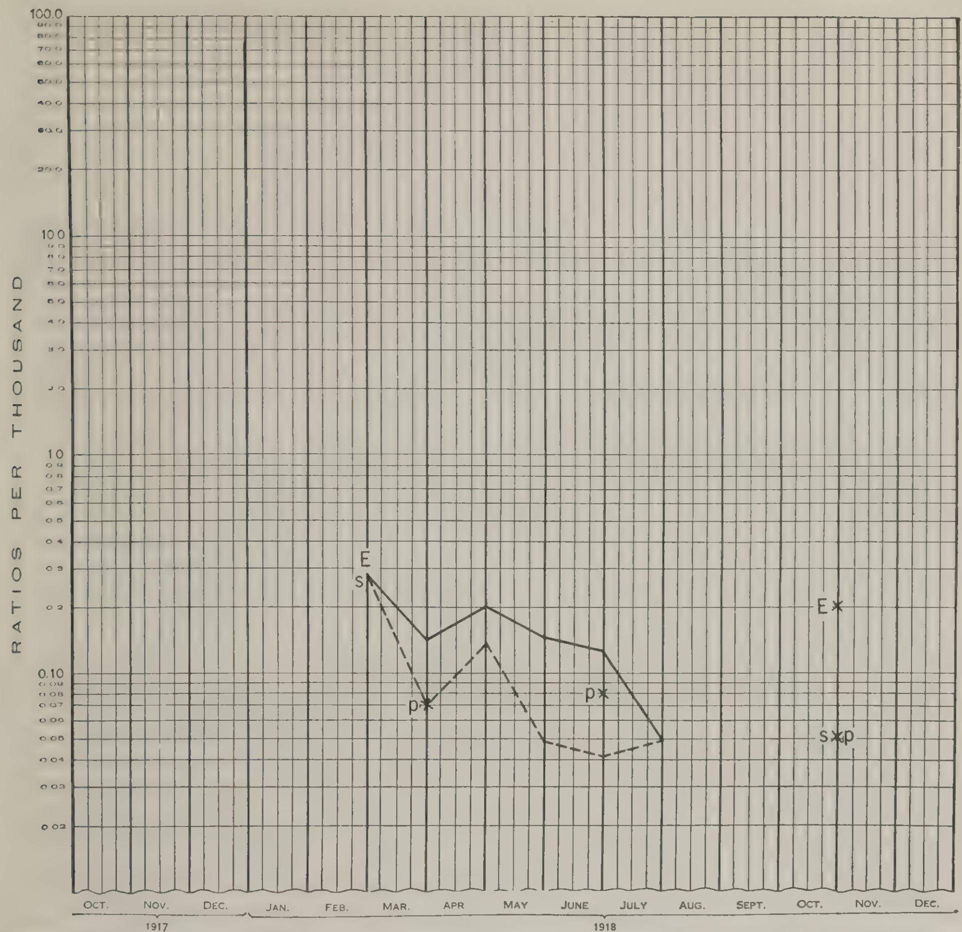


CHART XLVII.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Fremont, Calif.

TABLE 27.[a]—*Epidemiological table for Camp Fremont, Calif.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	0	0	0	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	0
1918.											
January	0	0	0	0	0	1.93	22.54	0	0	0	0
February	3	0	3	0	0	1.11	17.90	0.2814	0.2814	0	0
March	2	0	1	1	0	.60	25.40	.1403	.0701	0.0701	0
April	2	0	2	0	0	.29	86.71	.2057	.1370	.0	0
May	3	0	1	0	1	1.26	26.43	.1444	.0481	.0	0
June	3	0	1	3	0	1.09	18.92	.1248	.0415	.0830	0
July	1	0	1	0	0	.26	10.17	.0493	.0493	.0	0
August	0	0	0	0	0	1.88	13.72	.0	.0	.0	0
September	0	0	0	0	0	.44	13.53	.0	.0	.0	0
October	2	0	1	1	0	13.17	112.50	.2043	.0513	.0513	0
November	0	0	0	0	0	1.14	24.35	.0	.0	.0	0
December	0	0	0	0	0	.70	17.55	.0	.0	.0	0
	17	0	10	5	1	....	....	....	....	....	0

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

CAMP LEWIS.

Camp Lewis, Wash., about 13 miles from Tacoma, a city of over 100,000 population, was a National Army cantonment. The drafted men came from Washington, Montana, Utah, California, Idaho, Wyoming, and a few from New York State.[10] In September, 1917, the mean strength was 18,000, and the following three months it stood at about 36,000.[10] Colored troops were present, but in small numbers in October, 1917, and continuously thereafter. Frame barracks were provided for quarters.[10]

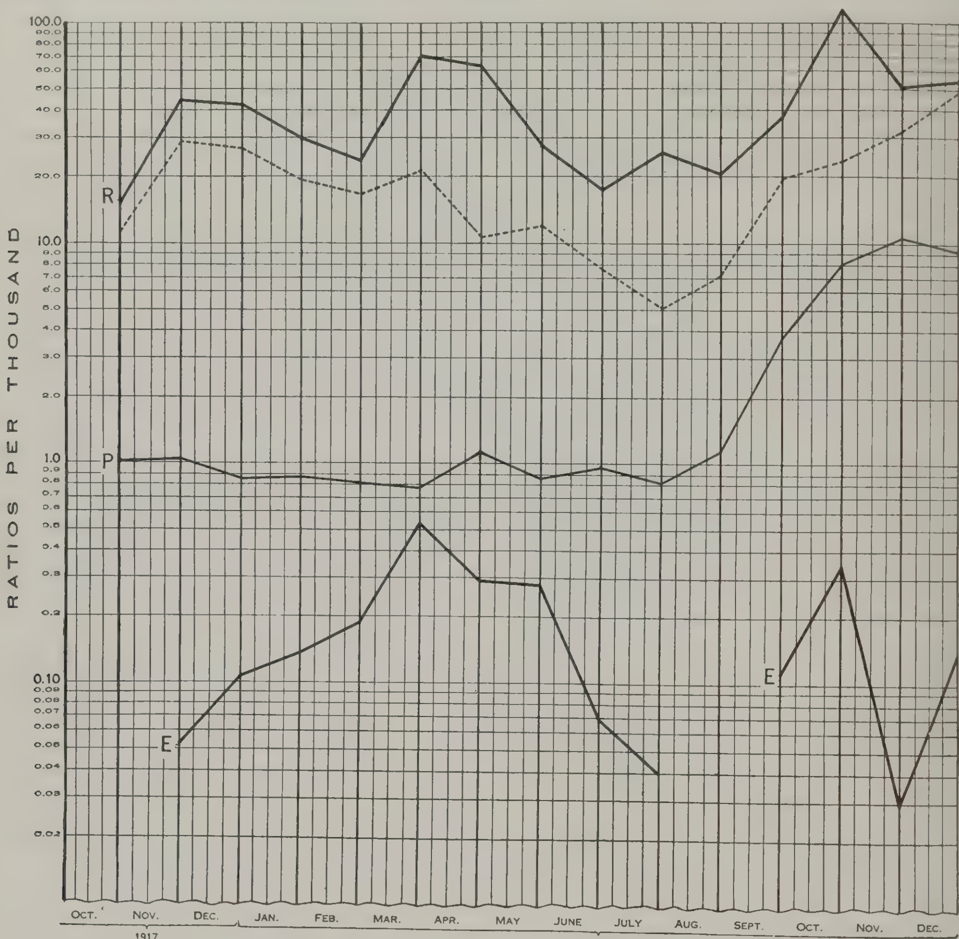


CHART XLVIII.—Epidemiological chart for Camp Lewis, Wash., in monthly ratios per thousand men.

During January, February, and March, 1918, there were five cases of postmeasles empyema, one of which died.[11] These five cases constituted 1.6 per cent of the total admissions for measles during the three months. The mortality among the postmeasles empyema cases was 20 per cent, which is a lower rate than that in many other camps.[11]

There was one case of empyema following rubella.[11] This occurred in December, 1917, when there were 1,063 admissions for the latter disease. As elsewhere, so here, there appears to be no significant relation between the two conditions.

Two out of 3,690 cases of mumps developed empyema.[11]

Among the 500 scarlet fever cases, none, followed by empyema, is reported.[11]

The proportion of streptococcus empyema was similar to that which obtained in so many of the eastern camps. The findings are reported for nearly 80 per cent of the cases, and of these 75 per cent were streptococcus and 25 per cent pneumococcus.[11]

The high incidence of total respiratory diseases at Camp Lewis is attributable to cases of uncomplicated influenza of a mild character.

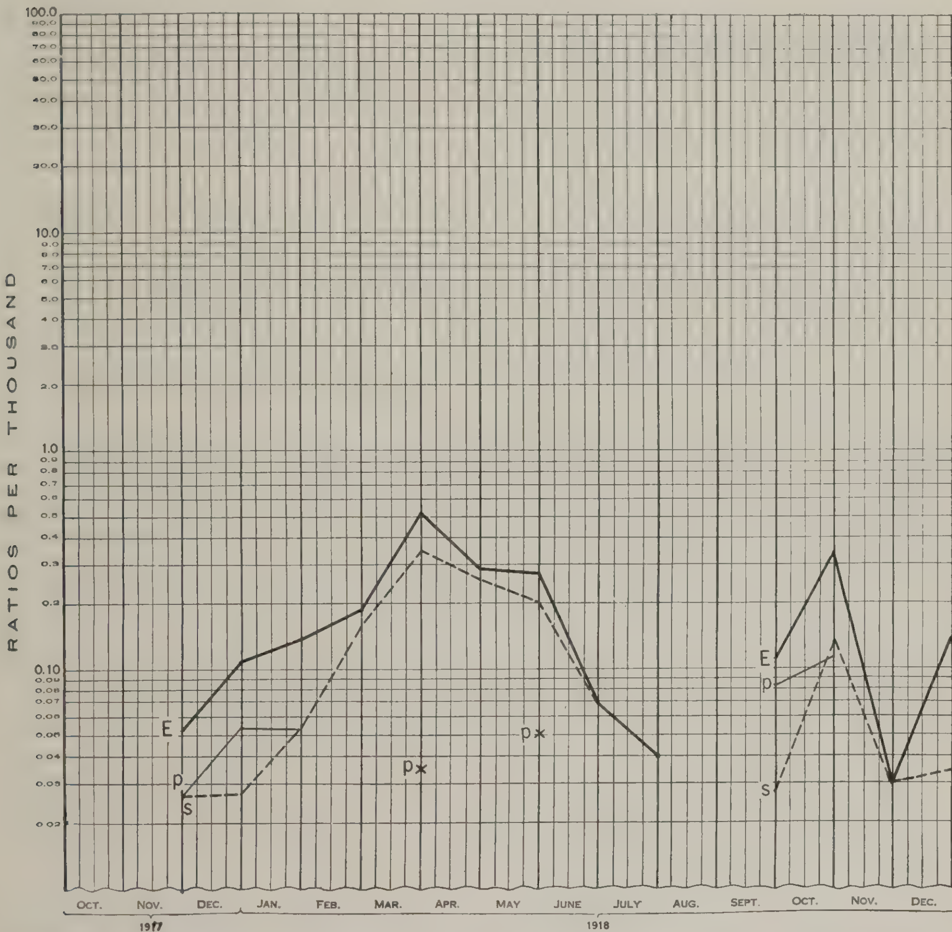


CHART XLIX.—Relationship of the pneumococcus and the streptococcus to the incidence of empyema at Camp Lewis, Wash.

In Chart XLVIII for Camp Lewis a dotted line gives the incidence of common respiratory diseases. If the cases of influenza are added to this, the curve "R" is obtained. In preparing the charts for the various camps the above separation has not been made, because it was doubtful whether cases reported as influenza would be consistently similar in all parts of the country. Except during the great epidemics, the diagnosis "influenza" does not very clearly define the exact nature of the affection to which it is applied. It appears certain that in different localities the practice in using this term varied.

Under the circumstances, the safer course to pursue for epidemiological studies appeared to be to include influenza among the diseases of the upper respiratory tract. A pharyngeal inflammatory reaction appears to be a constant manifestation of this disease, while a true pneumonia is developed in only a limited number of cases.

The chart for Camp Lewis very clearly exhibits the closer analogy of the empyema curve to that of upper respiratory diseases than to that of the pneumonias. While the pneumonia curve takes a nearly horizontal course up to July, the two former curves show wide fluctuations roughly corresponding to each other. The study of these relations in other camps has indicated that the occurrence of influenza disturbs in some degree an otherwise close parallelism between the curves for empyema and diseases of the upper respiratory tract. So here, the empyema curve takes a course which in general is intermediate between "R" and the dotted line representing common respiratory diseases alone.

TABLE 28.[a]—*Epidemiological table for Camp Lewis, Wash.*

	Absolute numbers.					Ratios per 1,000 men.					Empyema, mortality percentage.
	Empyema, totals.	Empyema, deaths.	Streptococcus group.	Pneumococcus group.	Staphylococcus.	Pneumonia.	Common respiratory diseases.	Empyema.	Streptococcus group.	Pneumococcus group.	
1917.											
October	0	0	0	0	0	1.06	15.04	0	0	0	0
November	2	0	1	1	0	1.16	44.09	0.0533	0.0263	0.0263	0
December	4	1	1	2	0	.86	42.56	.1082	.0271	.0542	25
1918.											
January	5	0	2	2	0	.89	29.92	.1368	.0548	.0548	0
February	6	2	5	0	0	.82	23.58	.1864	.1551	.0	33
March	15	1	10	1	0	.78	70.95	.5249	.3486	.0349	7
April	9	1	8	0	0	1.14	63.09	.2879	.2558	.0	11
May	11	0	8	2	0	.86	27.27	.2758	.2005	.0501	0
June	3	1	3	0	0	.96	17.18	.0681	.0681	.0	33
July	1	0	0	0	0	.81	25.71	.0393	.0	.0	0
August	0	0	0	0	0	1.14	20.61	.0	.0	.0	0
September	4	0	1	3	0	3.63	36.31	.1104	.0277	.0831	0
October	12	1	5	4	0	8.12	112.95	.3382	.1338	.1126	8
November	1	0	1	0	0	10.88	51.91	.0293	.0293	.0	0
December	4	0	1	0	0	9.25	54.34	.1345	.0336	.0	0
	77	7	46	15	0	....	....	....	....	....	9.1

[a] Sources of information: 1. Reports of sick and wounded made to the Office of the Surgeon General. 2. Special empyema reports made to the Office of the Surgeon General.

SUMMARY AND CONCLUSIONS.

In the preceding studies of the 23 individual camps there are singularly few instances where the curve representing the incidence of empyema has failed to conform to that of infections of the upper respiratory tract. In several camps the parallelism between these curves is strikingly close. Frequently, the way has been indicated in which the empyema curve is entirely interrupted when the curve for this class of respiratory diseases approaches its minimum. In several camps this absence of empyema is first noticed when the admissions for these respiratory diseases reached 10 per 1,000 men in the command, or 1 per cent.

Cases of empyema again appeared among men coming to the hospital at a time when the admissions for upper respiratory diseases rose above 1 per cent of the men in camp. It has also been learned that when a case of empyema

does occur during a period of low common respiratory incidence, there is often some exceptional feature in this case which either reduces its epidemiological importance, or else supports the inference that there is a direct connection between infection of the upper respiratory tract and the development of empyema.

When the parallelism, so frequently adverted to, is disturbed by a rise in one curve which is not reflected in the other, it has most frequently been at periods when there was an exceptionally high incidence of influenza. If these cases were mild, as shown by a low mortality, the incidence of empyema has been disproportionately low, the empyema curve being less affected than the curve for respiratory diseases. When the mortality from influenza has been greater, the empyema incidence has risen more rapidly in proportion to the rise in incidence of respiratory diseases. These differences in the excursions of the two curves on different occasions probably may be accepted as evidence that the development of empyema is not directly dependent upon the influenza, but rather upon associated infections of the upper respiratory tract, the effects of which are augmented by this disease.

A comparison of the charts from different camps fails to show a fixed ratio between the empyemata and upper respiratory diseases. In some camps the average distance between the lines representing the two conditions is greater than in other camps. Therefore, it can not be asserted that such or such a percentage of men suffering from infections of the upper respiratory tract will develop empyema. This lack of a fixed ratio between these curves may depend upon variations in the infections of the upper respiratory tract, some being more prone to further invasion than others; or, it may be due to concomitant conditions in the environment which were different in the different camps.

To illustrate this, let Camps Pike and Upton be compared as offering striking contrasts in this respect. In March the ratio of empyema to the common respiratory diseases was 1:44 at Camp Upton, and at Camp Pike it was 1:119; but the incidence of common respiratory diseases at Camp Pike was slightly the greater (a difference of 5.4 cases per 1,000 men). At Camp Upton in this month there were 2.4 per cent of deaths within this group of respiratory diseases, while at Camp Pike there was none. Evidently the general severity of these affections at Camp Upton was greater than at Camp Pike, and complications were more likely to have occurred. In other words, the upper respiratory infections at Camp Upton were relatively more virulent. This is further shown by the pneumonias, which, while more numerous at Camp Pike than at Camp Upton, presented a lower mortality, the ratios being 20.6 per cent and 34 per cent, respectively. Turning now to the empyemata, the mortality among the 14 cases at Camp Pike was 36 per cent, and that at Camp Upton 50 per cent of the 40 cases. The predominating organism in the pleural fluids at both places during this month was streptococcus.

Therefore, in so far as it is proper to accept the rate of mortality as an indication of the general virulence of an infection, it is evident that the respiratory diseases at Camp Upton were occasioned by relatively more virulent infections than at Camp Pike.

It would not be justifiable to attribute this difference in virulence wholly to variations in the particular strains of streptococcus in the two camps; there are too many other factors involved to warrant so simple a conclusion. Such things as the general physical condition of the men, the exposures to inclement weather or excessive fatigue, differences in race, and in previous modes of life might influence the relative virulence even though the strain of the organism were the same.

There are no data which could be used profitably in exploring the maze of possibilities suggested by the foregoing considerations. It must suffice to infer that at Camp Upton the resultant of all the factors involved was equivalent to there being present in that camp a virulent strain of streptococcus not very widely disseminated among the men, while at Camp Pike a less virulent strain was more widely distributed. Such an inference is supported by the peaks in the curves at Camp Upton in contrast to their more uniform levels at Camp Pike. This abrupt invasion by a virulent organism at Camp Upton, if it really was this, coincides in time to the arrival of over 7,000 men from other camps.

It is evident that the questions touched upon in the preceding paragraphs could be more satisfactorily discussed had there been available records of bacteriological surveys of the throats of men already in camp, and of new contingents upon their arrival. Such data are lacking.

In the foregoing studies of individual camps the bacteria reported as present in the pleural fluids have been broadly placed in three groups. So few cases have been associated with a staphylococcus that they offer little of epidemiological importance. But the group of streptococci was evidently of preponderating influence in the autumn of 1917 and in the early months of 1918.

In few of the camps are there records of a careful distinction between the types of pneumococcus found in the exudates. Where this was made, however, it is of some significance that Type IV appeared associated with cases similar in character to those in which the hemolytic streptococcus was found. A grouping of cases based on the significance of the associated microorganisms might not unreasonably include those in which the pneumococcus, Type IV, was found in the same group with those yielding the hemolytic streptococcus.

Epidemiological studies are fruitful in proportion to the practical lessons that may be extracted from them.

There are few obvious lessons conveyed by the study of the 23 camps that have furnished the material used in this chapter, but these lessons are clear and directly practical.

When the incidence of disease of the upper respiratory tract assumes such proportions that 1 per cent of the command is referred to the hospital for treatment, it becomes almost certain that cases of empyema will develop, and that the empyema cases will increase in proportion to a rise of those particular respiratory diseases. It is probable that the increase of these infections is indicative of the presence among the men of strains of bacteria prone to involve the pleura. But whatever the explanation may be, the period of danger starts at this definite time.

This offers a forewarning of the approach of serious conditions which might be averted by suitable preventive measures. It should impel regimental surgeons to direct particular attention to the condition of the nasopharynx

and tonsils of the men in their charge. The dissemination of infections of these parts should be guarded against, through measures reducing as far as practicable direct and indirect contacts between those having, and those still free from troubles of this character. It is believed also that there is such a thing as a hygiene of the nose which is very commonly neglected. The health

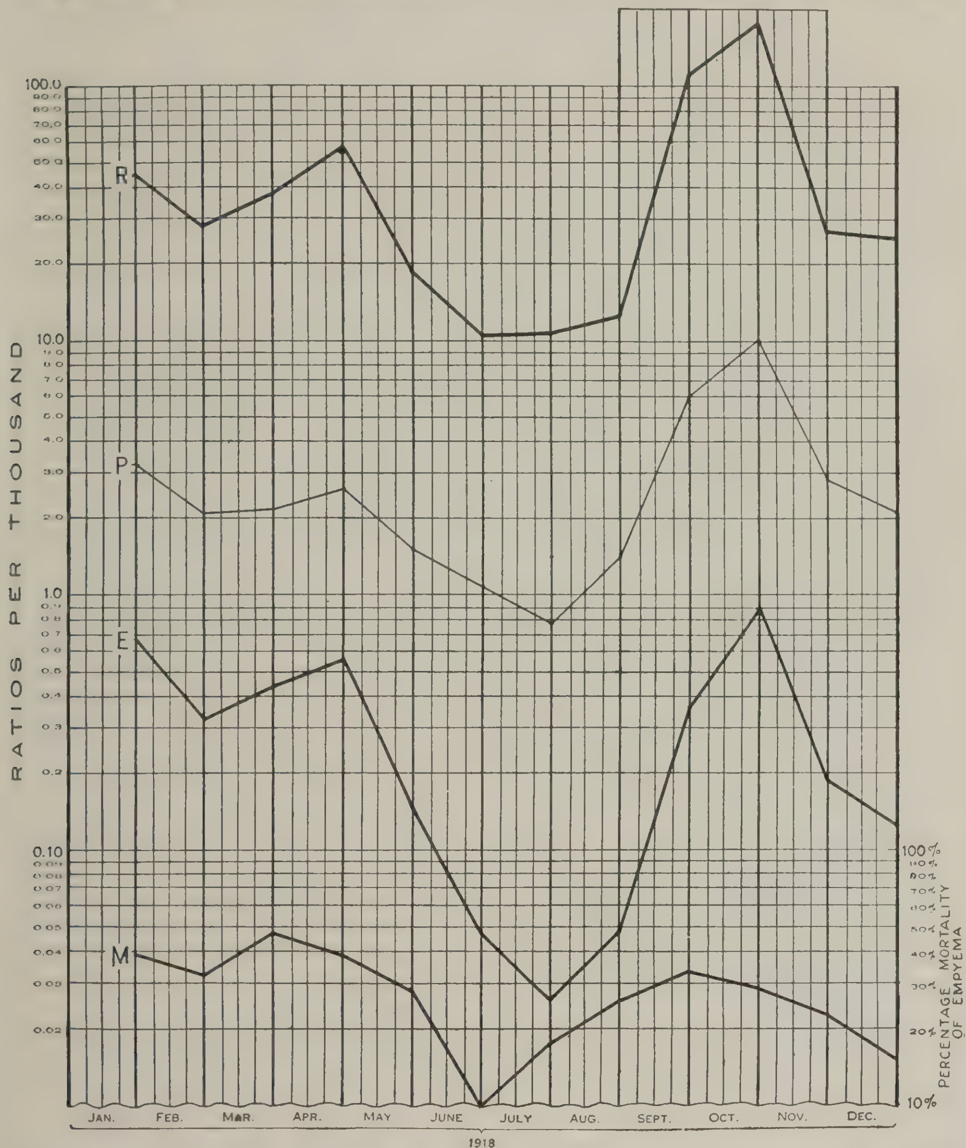


CHART L.—The incidence of respiratory diseases, pneumonia, and empyema in the Army camps and cantonments in monthly ratios per thousand men.

of the nasal mucosa certainly can be promoted by the removal of accumulated secretions and these parts invigorated by proper functional exercise. With this in view, mouth breathing, whether by day or night, or while doing even heavy muscular work, should be discouraged, and it appears rational to believe that special breathing exercises, including forcible expiration through the nose, would prove beneficial in promoting resistance to infection.

The foregoing are preventive measures applicable to men who are free from infection at the time. They are based upon experience among people in civil life as well as those in military organizations, but statistical data supporting them are meager.

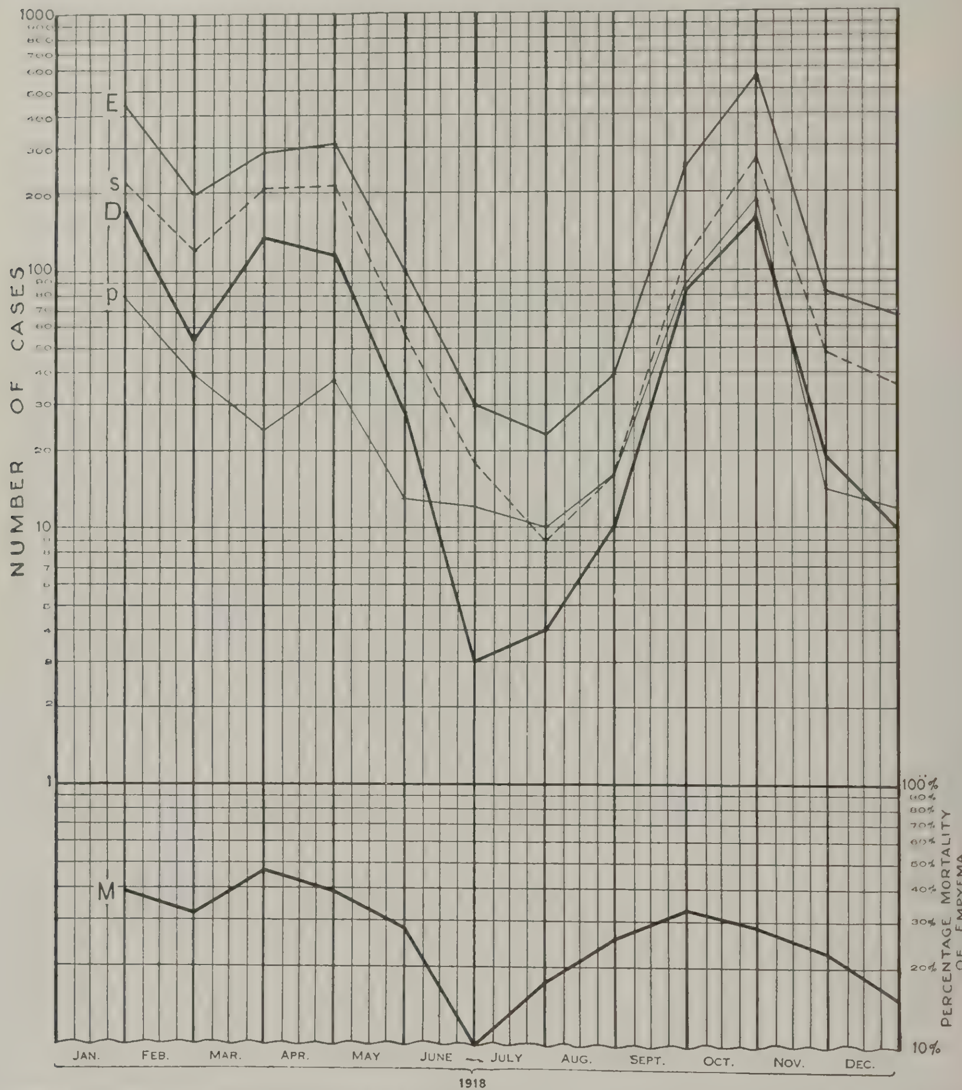


CHART LI.—Relationship of the empyemata due to streptococci and pneumococci to the mortality in the Army camps and cantonments—Absolute numbers.

REFERENCES.

(1) Special Empyema Report. On file, Record Room, S. G. O., 710 (Empyema, Camp Devens).

(2) Monthly report of sick and wounded to the Office of the Surgeon General (Manual for the Medical Department, 1916, par. 457).

(3) First Indorsement to letter from The Adjutant General to the Quartermaster General, March 21, 1917, noting approval of Secretary of War to plans. On file, Mail and Records Division, A. G. O., 2555459 (Old Files).

(4) Report of the Chief of the Construction Division, War Department, 1918, 14. On file, Record Room, S. G. O., Document File.

(5) Code cards, Measles. On file, Medical Record Division, S. G. O.
(6) Empyema Records. On file, Division of Surgery, S. G. O. (Empyema).
(7) Compiled from laboratory reports. On file, Record Room, S. G. O., 730 (Laboratory Technology).
(8) Report on replies to questionnaire on empyema of February 21, 1918. On file, Record Room, S. G. O., 024.2 (Division of Surgery).
(9) Report on replies to questionnaire on empyema of February 21, 1918, Section 2, Pathology and Bacteriology. On file, Record Room, S. G. O., 024.2 (Division of Surgery).
(10) Annual Report of the Surgeon General, U. S. Army, 1919, Vol. I (Camps, United States), 127–617 (name of camp); *also:* Historical Reports of Camps. On file, Historical Division, S. G. O.
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CHAPTER III.

PATHOLOGY.

Such studies on the epidemiology of empyema as were made possible by the information gathered through the channels described in the first chapter show that streptococci (usually hemolytic streptococci), or some variety of pneumococcus, have been most frequently found in the pleural fluids. Other organisms, a staphylococcus or the influenza bacillus alone, have been reported in some cases, but such instances are of comparatively rare occurrence. When these organisms were present, they were usually associated with streptococci and appear to have had little influence on the character of the cases. From these observations it must be concluded that the hemolytic streptococcus and the various types of pneumococcus were the organisms causing the severe and often fulminating empyemata encountered among the troops in the Army camps. The subject of inquiry in this chapter is how these organisms gain access to the pleural cavity and other parts of the body, and the nature of the lesions occasioned by their presence.

In the preceding chapter a close relation has been shown to exist between the prevalence of diseases of the upper respiratory tract and the incidence of empyema. From the data presented, it appears evident that this tract is the primary portal through which the organisms, which ultimately reach the pleural cavity, gain entrance.

ROUTES OF EXTENSION OF INFECTION TO PLEURAL CAVITY.

There are three obvious routes offering a means for the extension of infection from the upper respiratory passages to the pleura: 1. The infecting organisms may be carried from the bronchial tree into the pulmonary alveoli and there excite an inflammatory exudate and an edema which extend into the areolar tissue underlying the pleural endothelium. The damage to the tissues, together with the production of serous exudate, offers an opportunity for the extension of the infecting organisms into these tissues and into the pleural cavity. This may be designated as the alveolar route. 2. The organisms may gain entrance to the interstitial tissues of the lungs through lesions in the bronchial lining and be carried along the spaces in the areolar tissue or through lymphatic channels directly to the pleural structures. The infection of the pulmonary alveoli would then be a less conspicuous consequence of the invasion. This mode of extension may be named the interstitial route. 3. The organisms may gain entrance to the circulating blood and be disseminated to different and widely separated parts of the body with local foci of infection wherever they find lodgment and the conditions are favorable for their development. This is the blood-stream route of dissemination.

It is by no means necessary to assume that a single one of the routes mentioned is the only one actually followed in any given case. An extension through one channel does not exclude a concomitant extension through one or both of

CUT SECTION OF LUNG SHOWING INTERSTITIAL BRONCHOPNEUMONIA OF STREPTOCOCCUS ORIGIN FOLLOWING MEASLES. ACCESSION NUMBER 606. ARMY MEDICAL MUSEUM.

the others. More than one route may be open, but it is likely that should one be the chief or more prominent channel of extension it would affect the distribution of lesions and so dominate the clinical course of that particular case.

For this reason it is important to consider first the probable consequences of a dominance of each of these possible routes and then to follow with an inquiry as to the manner in which cases of empyema may actually be grouped with respect to such possible routes for the extension of the infection.

THE ALVEOLAR ROUTE.

Were the infection to extend only through the open air passages and thus markedly to affect the alveolar structures of the lung before the pleural surface was reached, it is evident that a pneumonia would be manifest before the pleural infection attracted the attention of the clinician. Since the pleural structures would be affected gradually, the first prominent effect upon the pleura would be an exudate which might be serous, but more frequently would be fibrinous or serofibrinous in character, and the initial damage would be relatively mild in degree.

According to the path taken within the lung, the pneumonia would be lobar in distribution, or certain lobules scattered through the lungs might be primarily affected, thus constituting a lobular or bronchopneumonia. There might be an extension and a confluence of the pneumonic patches.

In the one case the initial symptoms would be those common in a typical lobar pneumonia with an initial chill and sudden onset of fever. The pulmonary signs would be most prominent from the onset and the infection of the pleura might not be evident until a fully developed empyema had become established.

Where there is a single empyema cavity, confined to that part of the pleura overlying a consolidated area or a portion of the lung already resolving, the sequence of events may be described as follows: The damage to the vessels and tissue elements of the pleura leads to an exudate in which the formation of fibrin promptly takes place. The inflammation results in a fibrinous pleuritis and the subsequent agglutination of the pleural surfaces approximately coextensive with the underlying pneumonia. If the process progresses to the formation of pus, the pus formation takes place within the fibrinous deposit. The fibrin is then absorbed and a single cavity is formed, closely confined by the peripheral agglutination. If the pus is not formed rapidly and in large amounts, granulations springing from the less damaged pleura at the periphery of the cavity lead to permanent fibrous adhesions. In this way a single cavity is formed bounded throughout its extent by granulation tissue.

The bacteria in such cases are probably invariably pneumococci. The exudate is moderate throughout. Fibrin is formed in moderate amounts in the initial stages, but undergoes digestion when pus is formed. The organisms not infrequently die and the pus becomes sterile. If this pus is evacuated the conditions are favorable for an obliteration of the cavity because the pneumonia resolves and the lung is capable of full expansion. The pleural surfaces are brought into contact, with a blending of the granulations covering them and the production of the permanent fibrous adhesions. The pliability

and thickness of these adhesions depend upon the thickness of the layers of granulations which developed before the evacuation of the abscess.

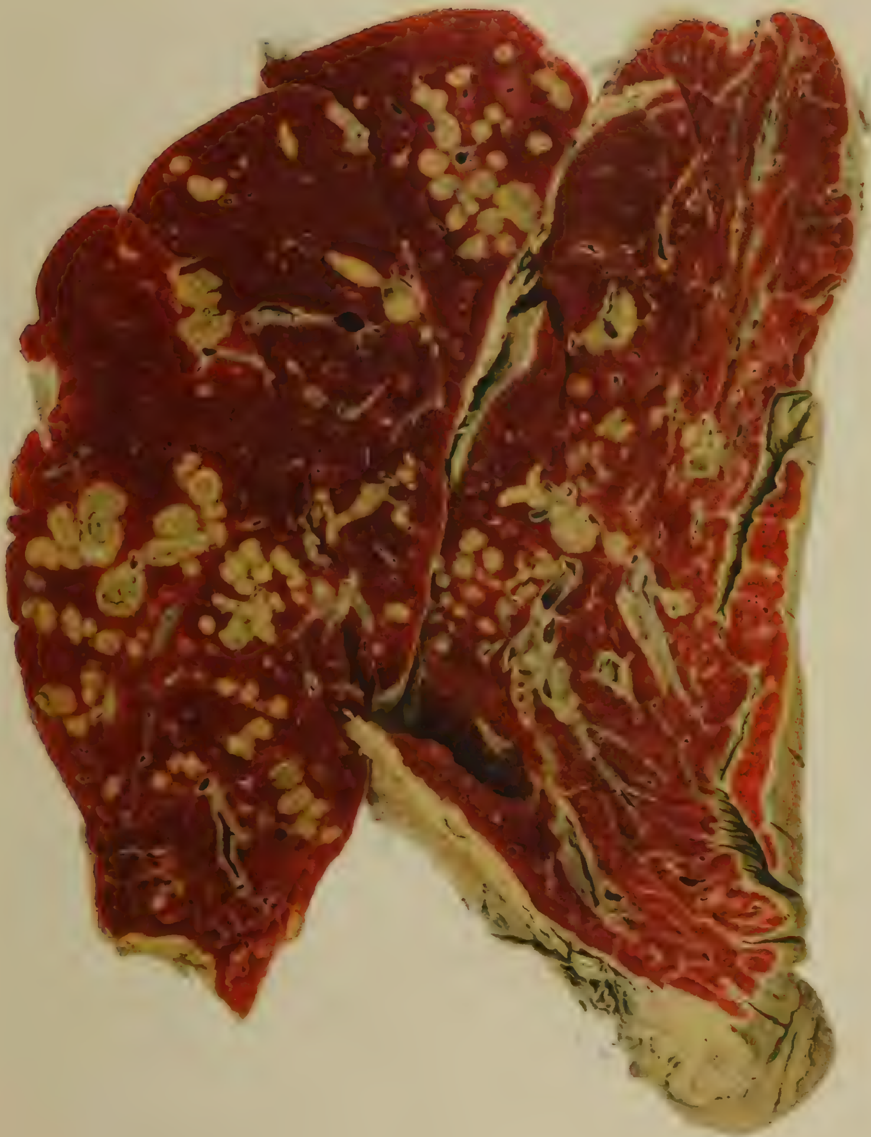
Should the extension of the infection be lobular in type, affecting several lobes, the physical signs would be diffused over wider areas of the chest. Such an infection might result in more than one empyema cavity. This is not, however, the only way in which multiple empyema cavities may be formed.

THE INTERSTITIAL ROUTE.

In contradistinction to the alveolar route, if the bacteria should gain entrance to the areolar tissues separating the lobules of the lung, the way would be opened to extension in all directions within the meshes of this loosely arranged tissue. The extension within the lymphatic spaces would be favored by the exaggerated respiratory movements and by the coughing and the vomiting accompanying the infection. In this way infection of the pleural tissues with pleural effusion might occur before signs of pulmonary consolidation were detected. Pleural pain would be one of the first symptoms and would be followed by an accumulation of fluid in the pleural cavity in sufficient quantity to veil the physical signs of a pneumonia. In other cases the effusion and consolidation would progress simultaneously so that the clinical picture would be that of a parapneumonic pleurisy.

Cases of this type are more frequently the result of streptococcus infection, and are generally characterized by an abundant exudate. Although fibrin is formed, agglutination of the pleural surfaces can occur only when these surfaces are in contact. With the patient lying prone on the back or on the unaffected side agglutination is most likely to occur anteriorly, so that a large cavity is formed in the posterior part of the chest with pockets along the anterior margin of the lung beneath the edge of the sternum. If the patient assumed a half reclining posture on account of dyspnea, the adhesions would be in the upper portion of the chest. The empyema cavity would then be inferior. Such localizations are abundantly illustrated in the records.

Were the infection to extend through the interstitial tissues, it need not be assumed that this extension would be only in the direction of the pleural surfaces, for it might be in the opposite direction toward the hilum of the lung. The direction taken by an infected fluid would be quite independent of the normal direction taken by the lymph; for in the event of severe infection accompanied by abundant serous exudation the competence of delicate structures such as the lymphatic valves could hardly be maintained nor would the bacteria necessarily be confined within the lymphatic vessels. Infections taking this course would involve the peribronchial and mediastinal lymph nodes and frequently would invade the areolar tissue of the mediastinum. Both the parietal pleuræ and the pericardium might be infected in this manner, as well as the areolar tissues in the neck. The infections might extend through the diaphragm into the meshes of the tissues underlying the peritoneum. It must be borne in mind that the tissues referred to are subjected to periodical respiratory alterations of pressure which promote the movement of lymph even in the absence of inflammatory processes stimulating its flow.



STAPHYLOCOCCUS INFECTION OF THE LUNG WITH MULTIPLE ABSCESSES. STAPHYLOCOCCUS AUREUS WAS OBTAINED FROM THE PLEURAL CAVITIES AND THE PERICARDIUM. ACCESSION NUMBER 1,141. ARMY MEDICAL MUSEUM.

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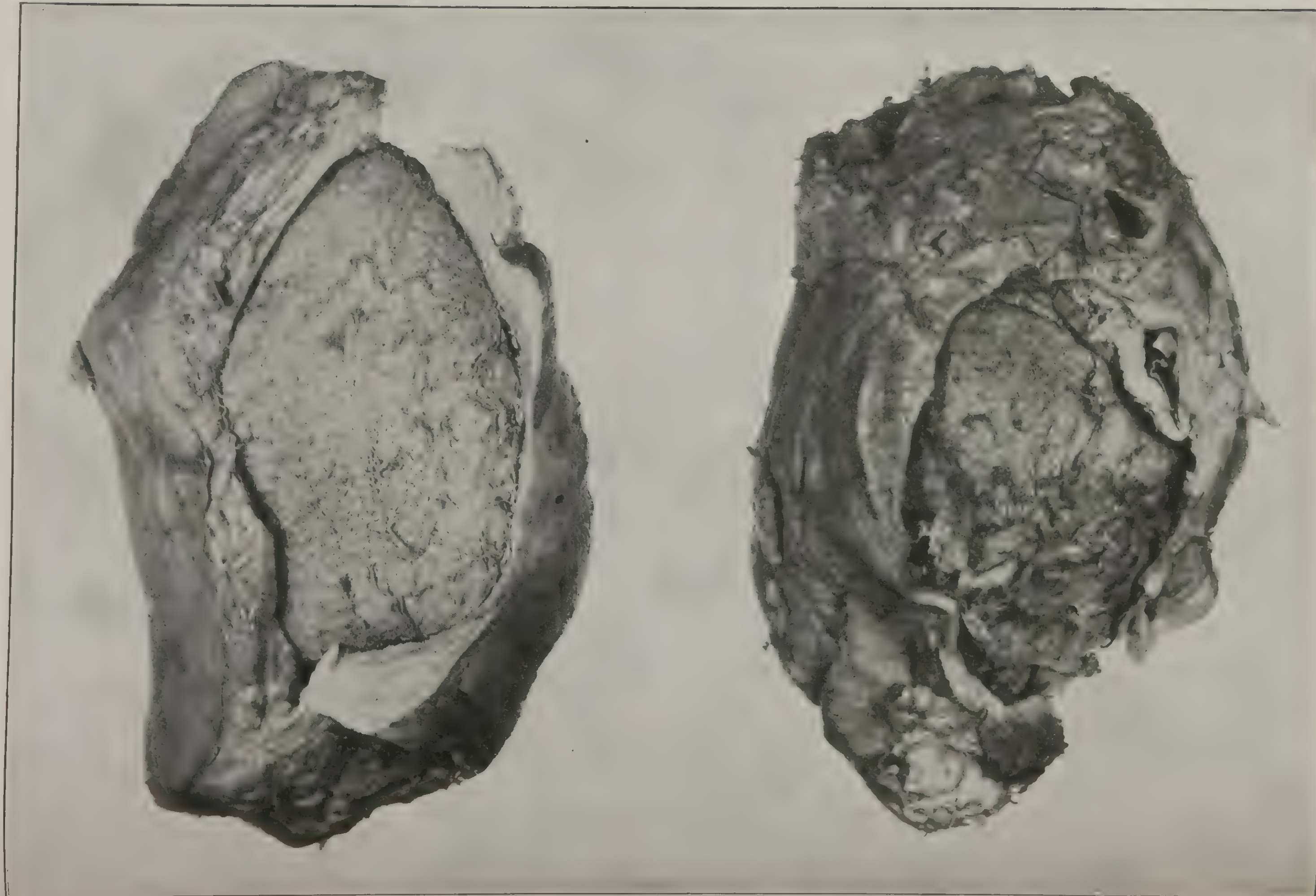
PLATE III.



FIBRINOPURULENT PERICARDITIS COMPLICATING AN INFECTION OF THE LUNG WITH HEMOLYTIC STREPTOCOCCI. ARMY MEDICAL MUSEUM ACCESSION NO. [illegible]

THE BLOOD-STREAM ROUTE.

This route of extension must be given a subordinate, though not unimportant, position. There are many instances in which distant parts have become the site of a secondary infection with the same organism found in the pleural exudate. Particular reference is made to arthritis in the wrist, ankle, or other joints, and to abscesses of the soft parts too remote to be explained readily by direct extension through lymphatic channels or areolar spaces. These can hardly have had any origin other than transmission by the circulating blood. The considerations set forth when sketching the other routes of dissemination indicate many ways in which the blood-stream might receive the infecting organism through local damage to blood vessels or through lymphatic drainage.[a] When the infecting organism is a pneumococcus, bacteriemia is known to be frequent. The direct evidence of a similar invasion of the blood current by streptococci is very much less impressive. The records contain many examinations of the blood for the detection of these bacteria, but there are few instances in which cultures have shown streptococci except during the few hours immediately before death. This does not preclude the occurrence of such an invasion as an occasional and transient event at any period in the course of some cases. There is no evidence, however, that empyema was primarily the result of a blood-stream infection. In certain instances empyema followed pneumonia occurring after an infection of the blood stream from distant foci.

EXTENSION OF RESPIRATORY INFECTION TO PARTS OTHER THAN THE PLEURA.

In the foregoing paragraphs the paths by which infection may reach the pleura have been the chief consideration. It would not be profitable to focus the attention solely on the pathology of the inflammatory processes affecting the pleura. Autopsies on many cases of empyema revealed inflammation in other parts of the body attributable to the same infecting organism. These were often of greater importance than the empyema itself. The infection was not confined to the lungs, but often involved the pericardium and peritoneum as well as soft parts far removed from the pleural cavities. The joints, the middle ear, the nasal sinuses, and the subcutaneous areolar tissue were frequently involved. These various localizations are not all attributable to the same route of infection, nor are they all secondary to the pleuritis for they have occurred before the latter could be recognized. Those of the accessory nasal sinuses and the middle ear may be occasioned by direct extension from the upper respiratory tract. Infection of joints and distant soft parts is generally referred to dissemination of the organisms by the circulating blood, the localization being determined by a slowing of the current through pressure, some form of local damage, or peculiarities in the vascular supply of the part affected. The frequent occurrence of pericarditis and of peritonitis has also been attributed to blood stream infection. While in many cases this actually may have been the route of infection, it is not the only rational explanation of the frequency of these thoracic complications.

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[a] Blake and Cecil (*Journal of Experimental Medicine*, 1920, xxxi, No. 5, 519) have observed invasion of the blood stream within six hours after intracheal inoculation of a monkey with virulent pneumococci. Such a rapid development of septicemia points to absorption through lymphatic channels.

Reports from some of the base hospitals have stressed the frequency with which pericarditis and peritonitis were associated with empyema. The authors of these reports have suggested that the organisms found in these cases showed a special predilection for serous cavities, and that the empyema was only one example of the affinity displayed by the bacteria for serous surfaces. Such reports can not but call attention to the anatomical relations of the pleuræ, pericardium, and peritoneum to the lymphatics and areolar tissue which lie immediately beneath all the intrathoracic serous surfaces, surround the intrathoracic viscera, and are continuous with the outer coats of structures passing through the diaphragm. It is necessary to consider the evidence pointing toward an extension through the mediastinal areolar tissue.

There is one striking illustration of the way in which dissemination may take place from the lung into the areolar tissues of the mediastinum, neck, and contiguous parts. This is offered by the interstitial emphysema which is not uncommon after postinfluenzal pneumonia and pleurisy. This interstitial emphysema is probably due to rupture of pulmonary alveoli, with entrance of air into the interlobular connective tissue. In such cases beaded rows of air bubbles can be seen beneath the visceral pleura; and they follow the interlobular septa to the hilum and into the areolar tissue between the parietal pleuræ of the two sides, then into the pericardium and the muscles and vessels of the neck; or the air may make its way into the subcutaneous tissues of the neck, shoulders, thorax, and abdomen. If air can be forced through these tissues there is no reason to believe that fluid may not follow the same route and that bacteria may not be carried with it.

In the great majority of cases such extensive dissemination did not take place. In the extremely fulminating cases, in which death occurred within a short time after the onset of symptoms, all the serous cavities were usually affected. This supports the view that extension through the mediastinal areolar tissue may actually occur. The mediastinal structures, however, were not always carefully examined at autopsy and bacteriologic examinations were rarely made. There are many reports of edema, purulent infiltration, or abscesses in the mediastinal tissues, and a few of phlegmons of the neck for which no obvious explanation could be found at autopsy. These findings would be expected if the mediastinal areolar tissues were infected. When pericarditis occurred later, after the acute infection had subsided, the infection probably took place through the damaged pleural tissue. There is no marked difference in the relations of the pericardium to the pleura on the two sides of the chest, and pericarditis has occurred at least as frequently with an empyema on the right side as with one on the left. Similarly, there can be no doubt that the diaphragm may be invaded by bacteria. A subphrenic abscess or a general peritonitis may occur in this way.

MEDIASTINAL INFECTIONS.

The data relative to the infection of the mediastinum through the lymphatic channels draining the infected portions of the lung are so extensive that they can be considered only briefly in this chapter. It is necessary, however, to bring together certain of these data to aid in the correlation of the pathology and the clinical material to be considered later.

Three possible modes of infection have been mentioned in the preceding paragraphs. The alveolar route of bacterial invasion can account for the infection of the lung and subsequent infection of the pleura by direct extension.

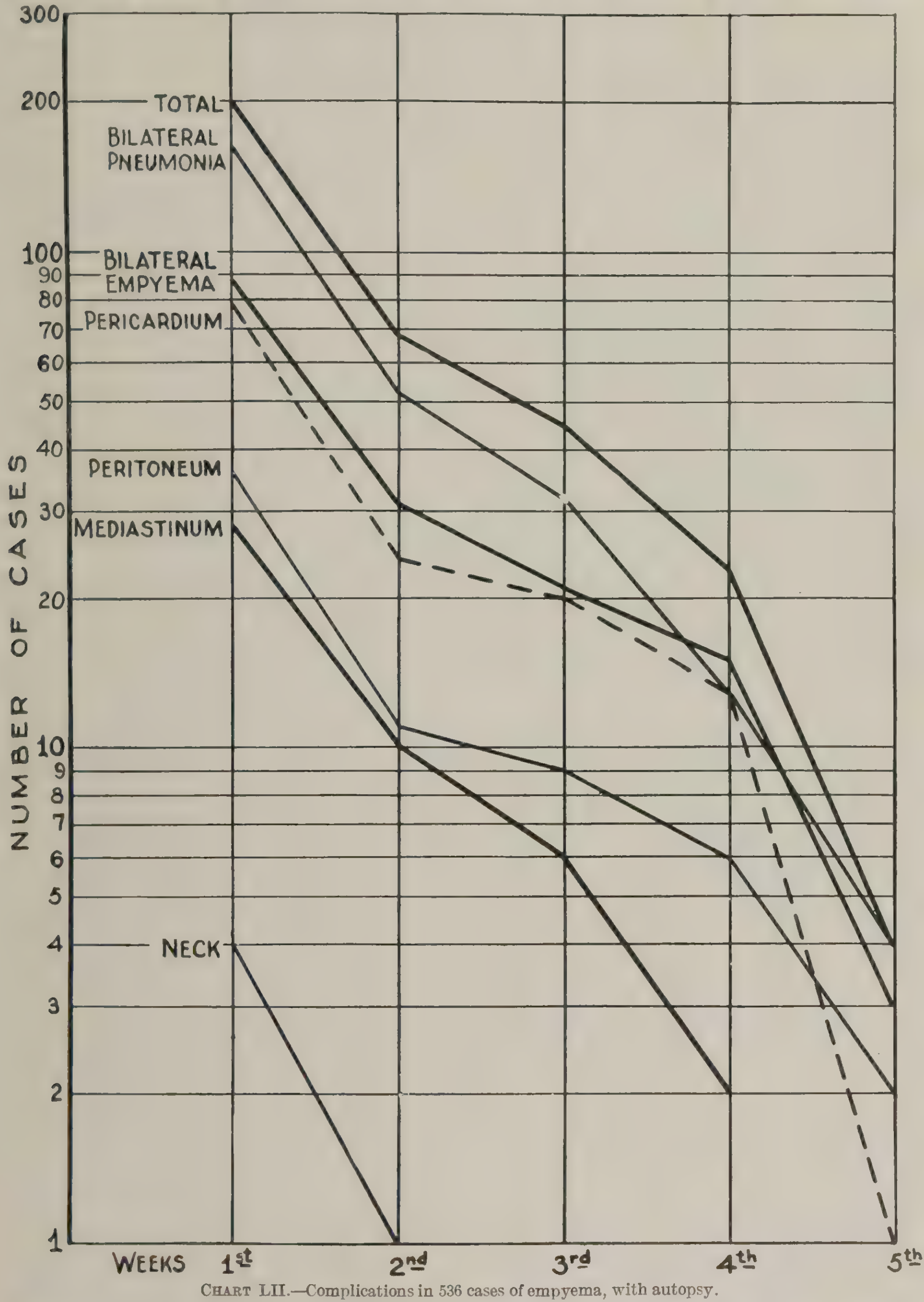


CHART LII.—Complications in 536 cases of empyema, with autopsy.

Further infection of the thoracic and abdominal viscera can not be as readily explained unless we assume that the bacteria are carried from the lung and pleura through lymphatic channels and the interstitial tissue to the mediastinum, pericardium, and peritoneum, or that they pass directly through the

pericardium and diaphragm. On the whole, there is little pathological or experimental evidence that the bacteria invade the serous cavities except through the lymphatics, since sections of the diaphragm and pericardium in the cases

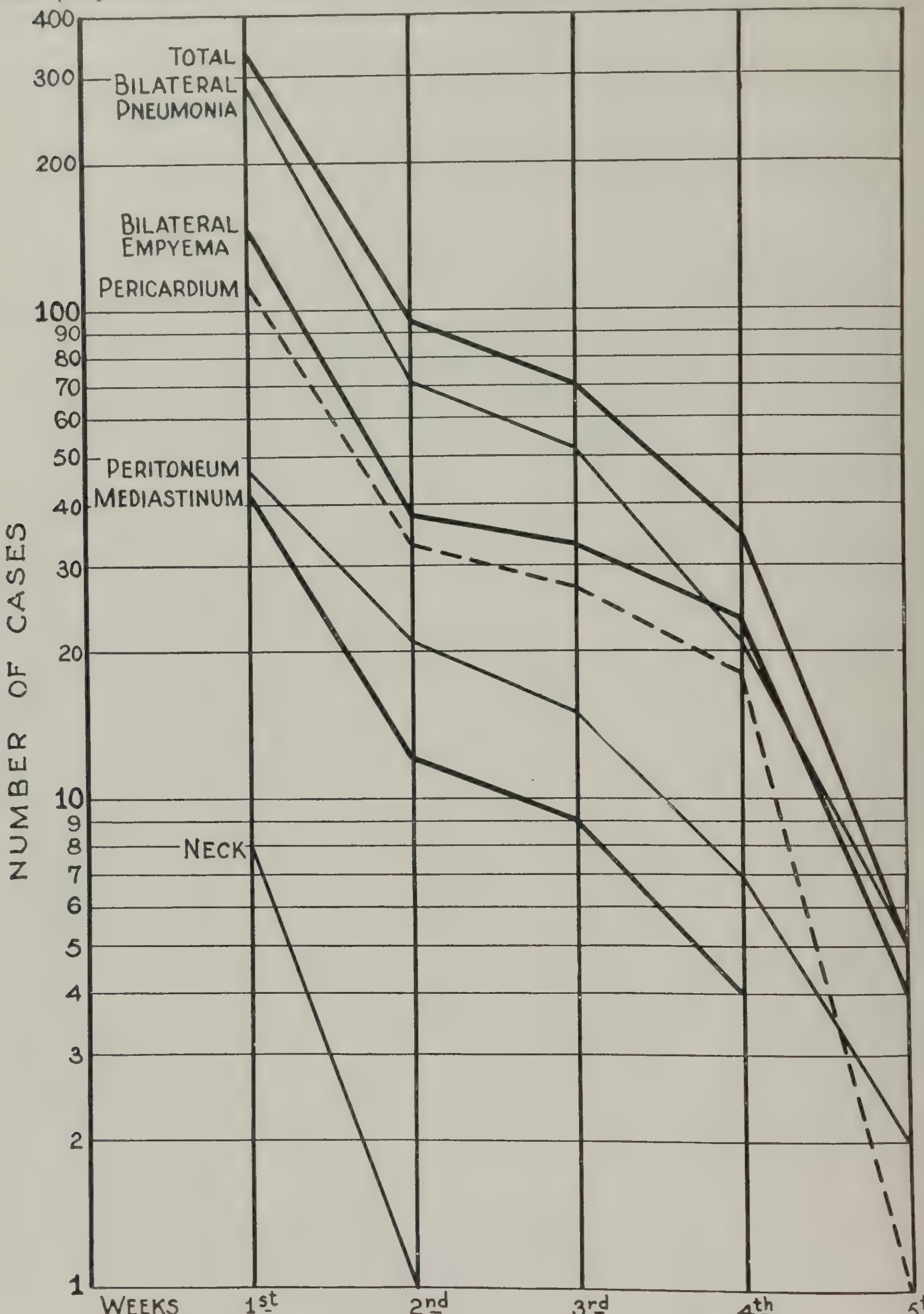


CHART LIII.—Complications in 339 cases of streptococcus empyema, with autopsy.

which have died with extensive infection do not show bacteria in the areolar tissue. Occasionally, bacteria may be found in the capillaries of the pericardium or diaphragm, but only in cases in which the blood cultures were

positive immediately before death or at autopsy. Since bacteria have been found in the blood stream ante mortem and in the capillaries post mortem, infection of the serous surfaces might have taken place through the blood stream. A serious objection to this view is the fact that the blood was seldom infected until immediately before death and not until there was previous clinical evidence of extension to the peritoneum or to thoracic viscera other than the lung and pleura. This is applicable, of course, only to streptococci.

A careful consideration of the gross pathology of cases of empyema has shown that there is a definite relation between all of these infections of the serous cavities and that this relation holds throughout a series of cases grouped according to the interval between the onset of the infection and the day of death. Tables 29 and 30 and Charts LII and LIII have been prepared to illustrate this relation.

Table 29 comprises an analysis of the autopsy findings in 536 cases of empyema grouped according to the week when the cases were terminated after the onset of the infection.[1] Six pathological conditions have been included. They are bilateral pneumonia, bilateral empyema, pericarditis, peritonitis, mediastinal infections and cervical infections. It is apparent from this table that the majority of the fatalities occur within the first week and that the complications in these cases occur most commonly in the order mentioned. Bilateral pneumonia, occurring in 86.7 per cent of the cases, is most frequent. Bilateral empyema is less common, since it occurs in 44.3 per cent. The other complications are found in 34.0 per cent, 14.2 per cent, 12.7 per cent, and 2.3 per cent, respectively. A similar analysis of the second, third, and fourth weeks shows that the percentage ratios of complications are practically identical throughout these periods. The fifth week shows considerable variations from the figures of the preceding periods but the number of autopsies is too small for accurate conclusions.

TABLE 29.[a]—*Five hundred and thirty-six cases of empyema, with autopsy showing complications—Deaths grouped in periods of one week after the onset of pneumonia.*

Period of death.	Total cases.	Bilateral pneumonia.	Bilateral pneumonia percentage.	Bilateral empyema.	Bilateral empyema percentage.	Pericarditis.	Pericarditis percentage.	Peritonitis.	Peritonitis percentage.	Mediastinal infection.	Mediastinal infection percentage.	Cervicalinfection.	Cervicalinfection percentage.
0-1 week..	332	288	86.7	147	44.3	113	34.0	47	14.2	42	12.7	8	2.3
1-2 weeks.	94	71	75.5	38	40.4	33	35.1	21	22.3	12	12.8	1	1.1
2-3 weeks.	70	52	74.3	33	47.1	27	38.6	15	21.4	9	12.9	0	0
3-4 weeks.	35	21	60.0	23	65.7	18	51.4	7	20.0	4	11.4	0	0
	531	432	81.4	241	45.4	191	36.0	90	16.9	67	12.6	9	1.7
4-5 weeks.	5	5	100	4	80.0	1	20.0	2	40.0	0	0	0	0
	536	437	81.5	245	45.7	192	35.8	92	17.1	67	12.5	9	1.7

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

TABLE 30.[a]—*Three hundred and thirty-nine cases of streptococcus empyema, with autopsy showing complications—Deaths grouped in periods of one week after the onset of pneumonia.*

Period of death.	Total cases.	Bilateral pneumonia.	Bilateral pneumonia percentage.	Bilateral empyema.	Bilateral empyema percentage.	Pericarditis.	Pericarditis percentage.	Peritonitis.	Peritonitis percentage.	Mediastinal infection.	Mediastinal infection percentage.	Cervicalinfection.	Cervicalinfection percentage.
0-1 week..	199	161	80.9	88	44.2	79	38.7	36	18.1	28	14.1	4	2.0
1-2 weeks.	68	52	76.5	31	45.6	24	35.3	11	16.1	10	14.7	1	1.5
2-3 weeks.	45	32	71.1	21	46.7	20	44.4	9	20.0	6	13.3	0	0
3-4 weeks.	23	13	56.5	15	65.2	13	56.5	6	26.1	2	8.7	0	0
	335	258	77.0	155	46.3	136	40.6	62	18.5	46	13.7	5	1.5
4-5 weeks.	4	4	100	3	75.0	1	25.0	2	50.0	0	0	0	0
	339	262	77.3	158	46.3	137	40.4	64	18.9	46	13.6	5	1.5

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

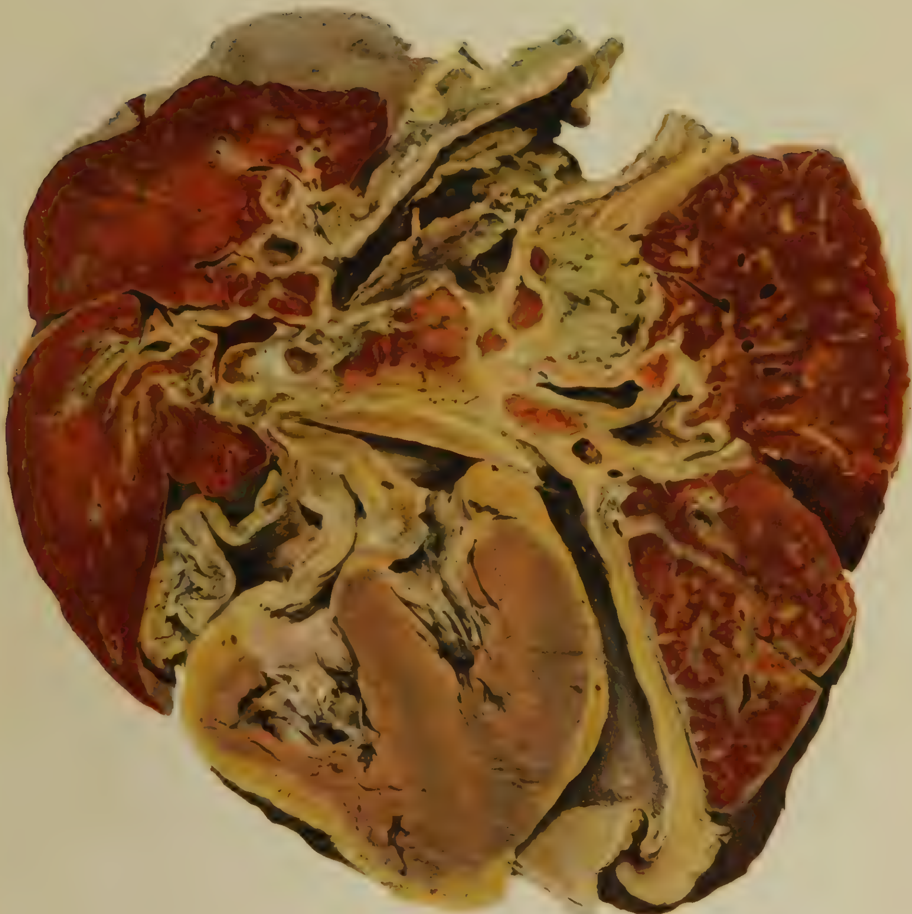
The cases in Table 29 include empyema irrespective of the organism causing the infection. Table 30 and Chart LIII comprise an analysis of 339 autopsies from which streptococci were recovered.[1] The same relations are found between the six pathological entities mentioned.

Such statistics are not conclusive, but suggest that infection may extend through the lymphatic tissues and invade the mediastinum, pericardium, and peritoneum. The one disturbing factor is the relatively low incidence of definite mediastinal infection. These findings, however, are not based on microscopic evidence, but merely on the gross appearance of the mediastinal tissues, so it is probable that in many of the instances there was an invasion of the mediastinum which had not yet resulted in sufficient reaction to be discerned microscopically.

An analysis of 67 cases with definite inflammatory lesions shows that streptococci were responsible for practically all of the infections. Microscopic study of sections through the lungs and mediastinum of these cases shows streptococci in the lymphatics and lymph nodes.

Figures 5, 6, and 7 are photomicrographic reproductions of sections from the fulminating streptococcus infections. They were stained by the MacCallum method at the Army Medical Museum in Washington. They illustrate the extent and character of the invasion of the lymph channels. Unfortunately the blood stream was infected in practically all these cases, so the possibility that the pericarditis and peritonitis, which were found post mortem, were not secondary to the bacteriemia rather than to the infection of the mediastinal tissues, can not be excluded. In one instance (Army Medical Museum, accession No. 6152) the pericardium and both pleuræ were infected and the post-mortem blood cultures were negative. The mediastinum was edematous; the lymph glands were enlarged and showed definite infiltration; and hemolytic streptococci were obtained from the intrathoracic serous cavities. Sections of the lung, mediastinum and pericardium, prepared from this case, have been photomicrographed to illustrate the lymphatic route of extension.

A consideration of these data brings out several important points. First, fatal cases of hemolytic streptococcus empyema die with a bilateral pneumonia and usually with extensive infection of two or more of the serous cavities. Intrathoracic complications are most common. The percentage relationship between these complications found at autopsy are similar throughout the first four weeks of the infection. Second, pericarditis and peritonitis occur, at times, before the bloodstream is infected. Third, infection of the pericardium may occur through the mediastinum. Fourth, it seems probable that the infection extends from the lung to the mediastinum, then to the pericardium and peritoneum through the lymphatics, and that the bloodstream is invaded through the lymphatics rather than by direct contamination from the infected lung.



LOBAR PNEUMONIA AND BRONCHOPNEUMONIA WITH PERICARDITIS AND MEDIASTINAL INFECTION DUE TO HEMOLYTIC STREPTOCOCCI. ACCESSION NUMBER 6,152. ARMY MEDICAL MUSEUM.

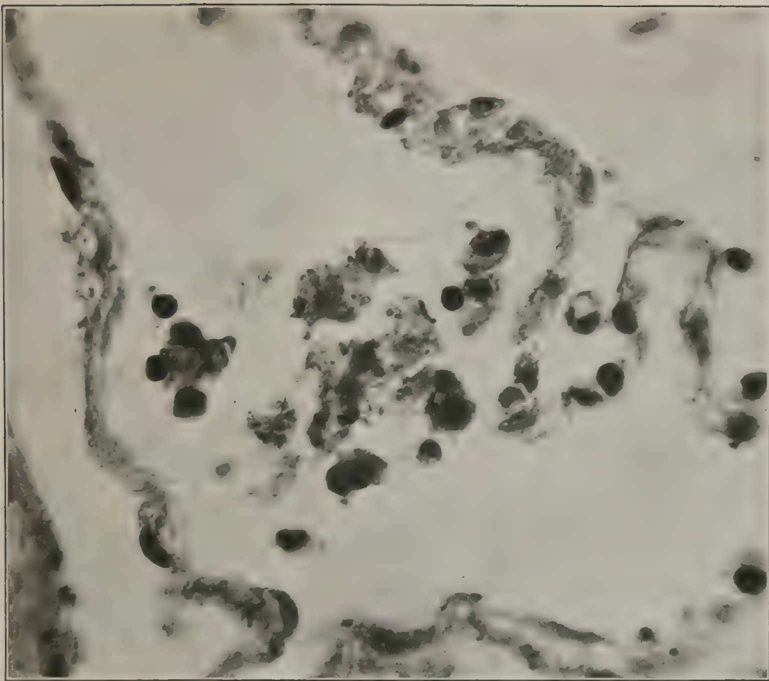


FIG. 5.—Streptococci in the intrapulmonary lymphatic channels in interstitial bronchopneumonia. Army Medical Museum, accession No. 3290. Negative 33024.

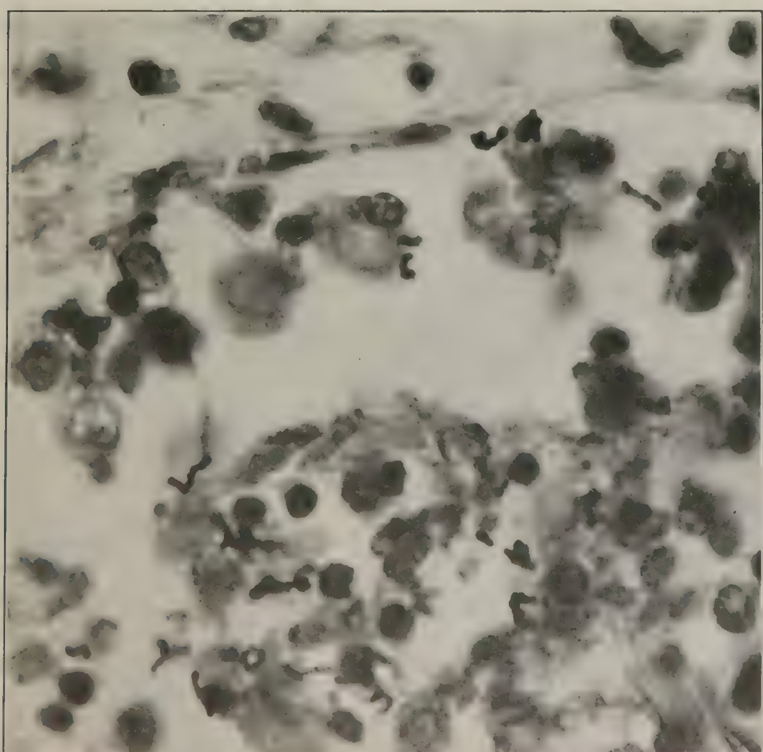


FIG. 6.—Section of mediastinal lymph gland. Army Medical Museum, accession No. 3300. Negative 33030.

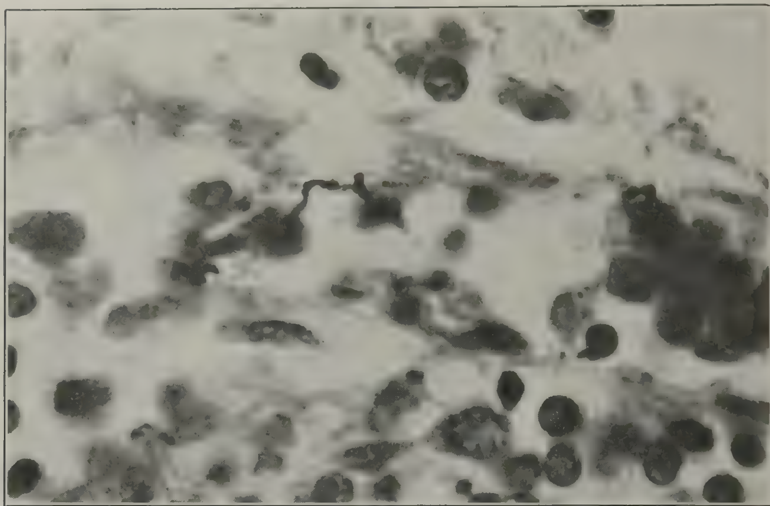


FIG. 7.—Hemolytic streptococci in peribronchial lymphatic channels. Army Medical Museum, accession No. 3300. Negative 33028.

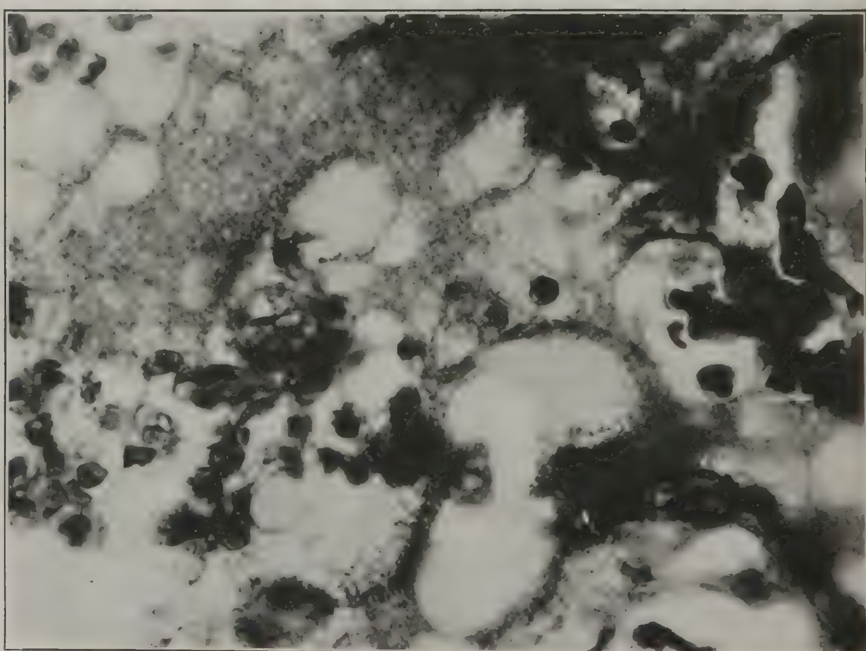


FIG. 8.—Streptococci in the peribronchial tissues. Cellular infiltration and the presence of fibrin are evidence of acute inflammation. Army Medical Museum, accession No. 6152. Slide 3a. Photographed at the Rockefeller Institute for Medical Research.

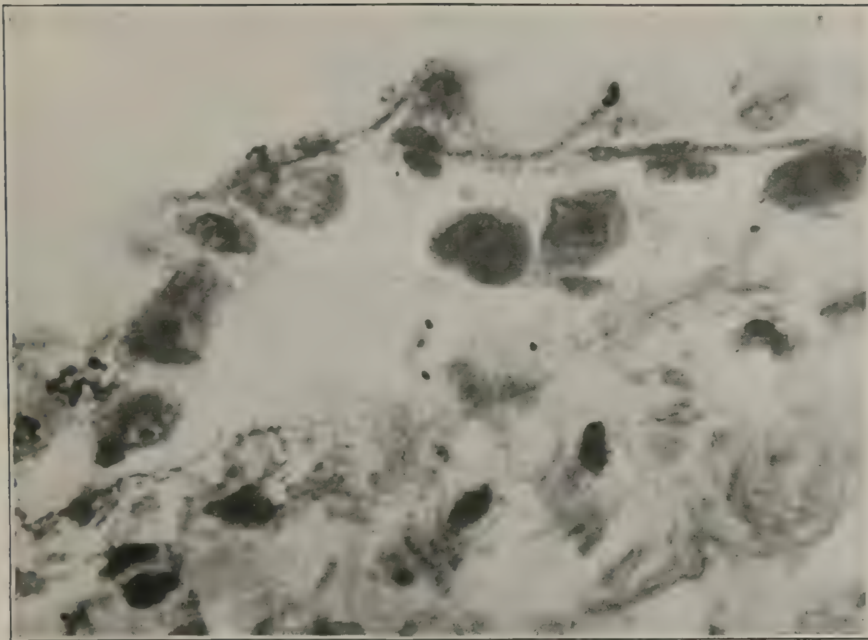


FIG. 9.—Section through mediastinal pericardium showing streptococci beneath the endothelial layer. Army Medical Museum, accession No. 6152. Negative 33027.

FIG. 10.—Streptococci beneath the endothelium in the subpericardial tissues of the mediastinum. Army Medical Museum, accession No. 6152. Photographed at the Rockefeller Institute for Medical Research.

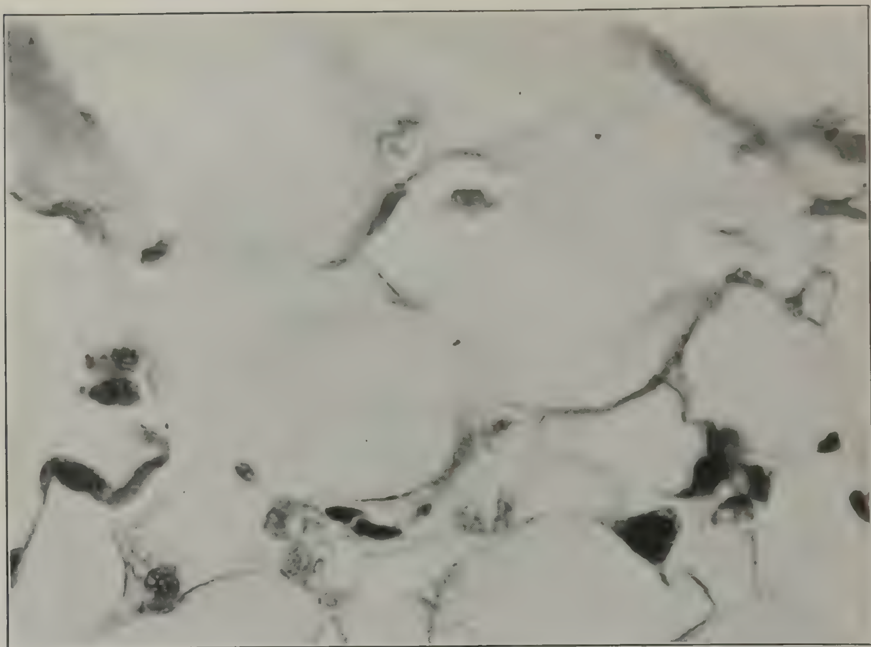


FIG. 11.—Streptococci in adipose tissue, hilus of the left lung. Army Medical Museum, accession No. 6152. Photographed at the Rockefeller Institute for Medical Research.

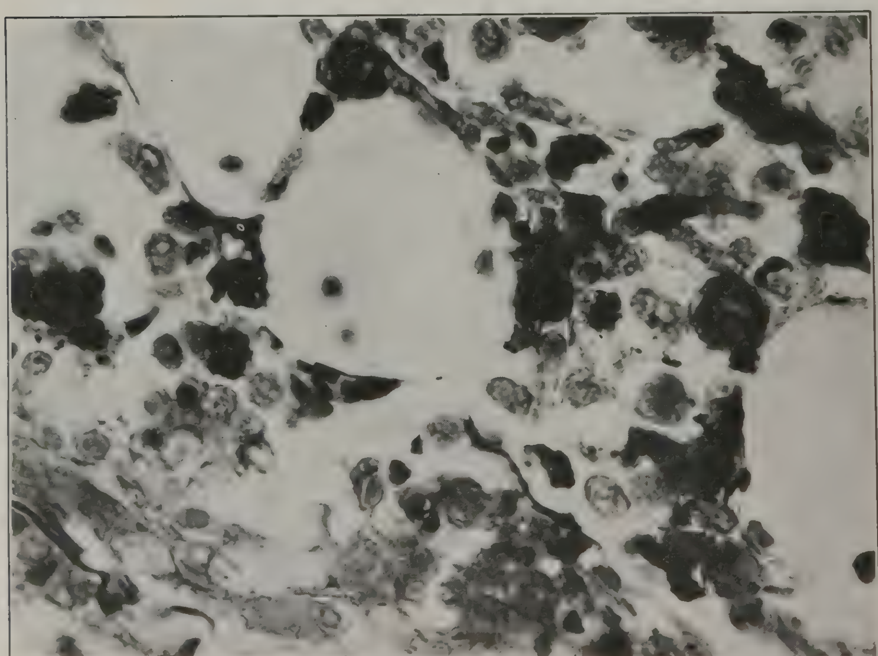


FIG. 12.—Streptococci in serofibrinous exudate in fat and areolar tissue of the mediastinum. Army Medical Museum, accession No. 6152. Photographed at the Rockefeller Institute for Medical Research.

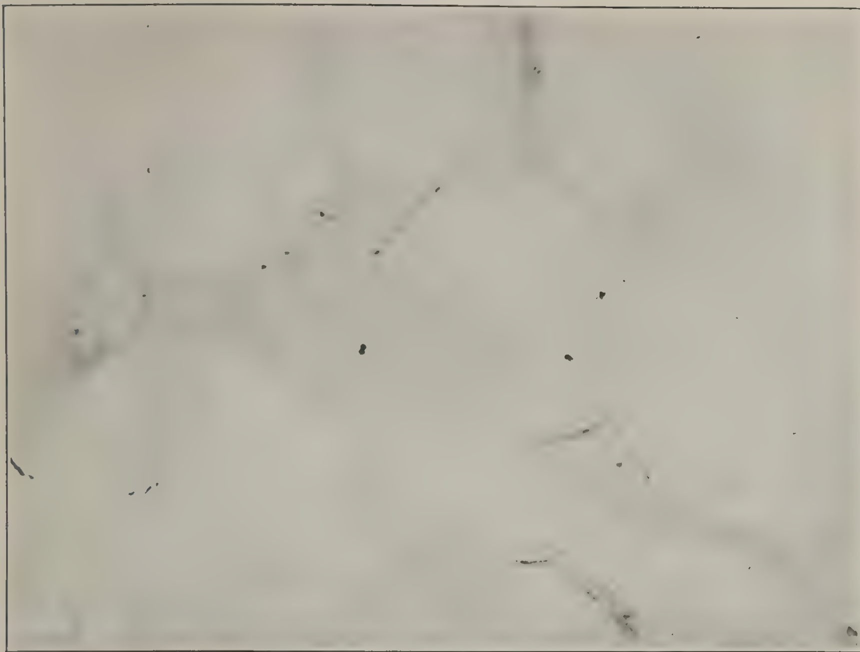


FIG. 13.—Streptococci in the adipose and areolar tissue of the mediastinum. Army Medical Museum, accession No. 6152. Photographed at the Rockefeller Institute for Medical Research.

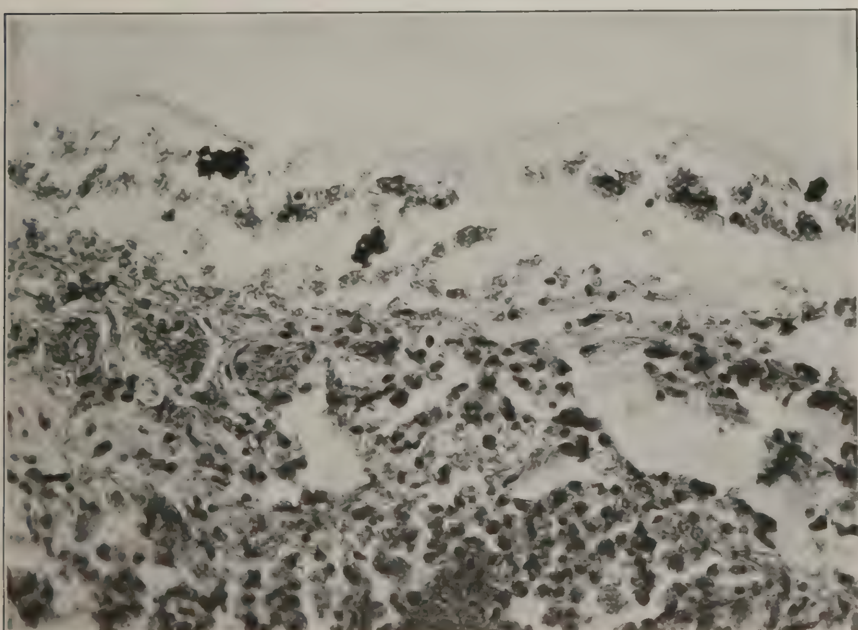


FIG. 14.—Early stage of pleuritis. Streptococci in the serous exudate beneath the endothelial layer. Army Medical Museum, negative 32446.

THE EFFECT OF THE TYPE OF PNEUMONIA ON THE EMPYEMA.

Quite aside from the possibility of such wide distribution of the infection to the serous cavities just referred to, the interstitial route of extension favors marked diversity in the localization of the empyema. Frequently, there were two or more empyema pockets on the same side of the chest. Sometimes the cavities were superficial, one wall being formed by the costal pleura; again, pockets were found between two lobes which were otherwise adherent; while in other cases pockets were discovered between the lung and the mediastinal pleura, either posterior, near the spinal column, or anterior, beneath the sternum or costal cartilages.

This varied localization of the pleural infection leads directly to an inquiry concerning the forms of pneumonia with which empyema was most frequently associated. This may well be the first detail considered.

Of particular value are the studies of pneumonia in Army camps made by MacCallum,[2] and by Opie and his associates.[3] It appears from these studies that in addition to typical lobar pneumonia, characterized by red and gray hepatization, and associated with a pneumococcus infection, there were numerous cases of pneumonia in which the lesions were scattered throughout one or both lungs. These lesions were distributed along the bronchial tree and for this reason constituted a bronchopneumonia. These pneumonias were almost invariably associated with hemolytic streptococcus. The lesions themselves were not, however, invariably the same. They fall into two main groups: 1. Interstitial bronchopneumonia. 2. Lobular pneumonia.

ACUTE (SUPPURATIVE) INTERSTITIAL BRONCHOPNEUMONIA.

Here the interstitial tissues of the lungs were greatly involved in the infection and the lymphatic spaces offered channels for the dissemination of the bacteria. Empyema was an extremely frequent complication of this form of pneumonia.

Within the lung the most striking lesions were in and about the bronchioles. The walls of the bronchi themselves were densely infiltrated with mononuclear cells and markedly thickened. Extreme hyperemia and the formation of blood vessels and of connective tissue added greatly to this thickening and to the deformity of the wall. In some cases the whole lining was necrotic and coagulated and constituted a diphtheritic membrane.[4]

This destruction of the bronchial wall at times extends to and includes the muscular coat, leading to such a marked weakening of the structures that they give way under the sudden pressures to which they are exposed. Clefts in the walls may result, leading to acute bronchiectasis. The productive interstitial inflammation which follows may restore again the normal lumen, or may simply lead to a thickening of the dilated bronchial wall and a persistent chronic bronchiectasis.[5] In other cases where the destruction of tissues has been less deep, the productive processes may predominate and a narrowing of the bronchial lumen be the ultimate result. When secretions, often tenacious in character, block this narrowed bronchus or bronchiole the corresponding portion of the lung may become atelectatic.

The adjacent alveoli show infiltration of the walls and are filled with blood, dense fibrin, and desquamated epithelial cells. These changes are less marked

in alveoli further removed from the main focus of infection in the bronchus, the cellular elements are here less abundant and lie in a thick, viscid fluid. To quote MacCallum:[6]

Streptococci may be found in tangled masses in the lumen of each bronchus or bronchiole mingled with the leucocytes of the exudate, but in most instances they are found in appreciable numbers in the substance of the tissue or in the alveolar contents.

The lymphatics which run from the pleural network by way of the interlobular septa, bronchial walls, and blood vessel walls to the nodes at the hilum of the lung quickly become a channel for the transport of these bacteria. Great numbers of them are found in these canals and in the sinuses of the lymph nodes at the hilum where they appear to be halted. They cause thrombosis of the lymph channels which become distended to an enormous size and appear to the unaided eye as most conspicuous beaded white strands on the cut surface of the lung extending to connect with the pleural network which may be in places similarly injected and distended with a white infected semipurulent thrombus. These lymphatics are often 2 to 3 mm. in diameter, which is not especially greater than the diameter of the normal channels, but they become conspicuous in a way seldom observed because of their yellowish white contents. Sometimes they might almost be confused with the obstructed bronchi.

It is thought that bacteria extend by growth along these obstructed channels in both directions and thus passing from the lung to the pleura (in a direction opposed to that of the current in unobstructed lymphatics) infect the walls of the pleural cavity and set up the intense inflammation with the outpouring of fluid exudate. The pleura itself and all the interlobular septa become edematous and permeated by a serofibrinous exudate with [microorganisms and] wandering cells.

From the beginning of the infection of the pleura the effusion of fluid exudate becomes a dominant feature of the whole process both in the clinical signs and the anatomical changes. It takes place with extraordinary rapidity and compresses the lung to such a degree as to complete the atelectasis.

LOBULAR PNEUMONIA.

This type of bronchopneumonia was also almost invariably associated with hemolytic streptococcus, but the bronchial and peribronchial lesions were absent. The streptococci invaded the alveoli, which became filled with blood, leucocytes and enormous numbers of these bacteria, giving rise to patches of consolidation, followed frequently by necrosis and peripheral hemorrhage.

This variety of pneumonia was prone to occasion multiple abscesses, lying mostly near the periphery of the lung, and extending to the pleural surface. A rupture of such an abscess into the pleural cavity, or an extension of the necrosis so as to involve the structures of the pleura, would inevitably lead to empyema, and the coincident communication of the abscess with a patent bronchus would establish the pleurobronchial fistulæ which not infrequently complicated the treatment. In the less fulminating cases this mode of pleural infection was very common, at least in many of the camps, and pleurobronchial fistulæ were doubtless of much more frequent occurrence than the records show. There appears to be a pronounced tendency for such lesions to heal and for the communication between the lung and pleura to close spontaneously after the empyema cavity has been evacuated. In most cases these openings are not large enough to permit escape of pus from the pleura into the lung and subsequent discharge by expectoration. The thick fibrinous deposit, usually present, suffices in most instances to prevent this occurrence.

MIXED TYPES OF PNEUMONIA.

Since the two varieties of bronchopneumonia just described are associated with hemolytic streptococcus disseminated through the air passages, it is not surprising that in many cases the lesions within the lung should present features characteristic of both the alveolar and interstitial routes of extension.

Furthermore, a mixed infection with pneumococcus and streptococcus may lead to a complex superposition or juxtaposition of lobar and bronchopneumonia. In such cases of mixed infection the pleural effusions and other associated infections are most frequently attributable to the streptococcus.

It is evident from these descriptions of pneumonia in the Army that the hemolytic streptococcus has been the cause of many of the peculiar characters presented by this disease among the troops. This organism appears in many, perhaps most, instances to have been a secondary invader. In the early period of high incidence many cases of empyema were preceded by measles, but this was by no means invariably the case. In the later period, influenza doubtless predisposed to a secondary invasion with streptococci. The data published by Opie and his associates [3] indicate that in the postinfluenzal pneumonias, pneumococci were relatively more frequently encountered than in the winter of 1917 and 1918, though infection with hemolytic streptococcus was also common. The pneumococci in the lobar pneumonias, however, were of types commonly found in throats of healthy people (50 per cent Types III and IV). It would appear that at both periods fortuitous circumstances favored the invasion of the lungs by organisms already in the upper air passages. In some cases the condition favoring this invasion appears to have been dependent on some antecedent disease, notably measles or influenza. In other cases there is no record of events to which a lowered resistance favoring extension of upper respiratory infections can be attributed.

The foregoing descriptions of pneumonia are in complete harmony with the epidemiological studies of empyema presented in Chapter II. They also indicate that both of the first two routes of extension actually occurred, namely, that by an intermediate alveolar infection and that through lymphatic channels.

It has been suggested by MacCallum [7] that differences in tissue resistance may play an important part in determining the character of the lesions in the lung produced by the hemolytic streptococcus; the interstitial pneumonias with rapid inflammatory reactions of a productive kind being evidence of greater resistance than the lobular pneumonias in which necrotic changes prevail.

With reference to the third route of dissemination—that is, through the blood-stream—the studies show that hemolytic streptococci were rarely found in the blood except immediately before death.[a] This is in sharp contrast to the results of blood cultures in cases of pneumococcus infection. Where it was known that both streptococcus and pneumococcus were present in the lungs or pleural cavity, the pneumococcus was frequently found in blood cultures while the streptococcus was absent. In these cases of mixed infection the streptococcus tended to persist in the lungs and pleura after the pneumococcus had disappeared. This circumstance justifies the precedence given to streptococcus in the epidemiological study, where these cases of mixed infection were placed in the streptococcus group.

From the studies of pneumonia cited above light is thrown not merely on the routes by which infection reaches the pleura, but also on the varying

[a] "We have made in all about 100 blood cultures from the circulating blood taken from the arm vein at various times before death with the usual technique of adding the blood to sterile broth, etc., but none of these cultures gave a positive result except when they were taken just before death." [8]

distribution of the pleural infection. In a typical lobar pneumonia the pleural infection is prone to be confined to the area of consolidation and appears to start as a dry pleurisy, with hyperemia and a fibrinous exudate tending to agglutinate the pleural surfaces and to restrict the pleural abscess subsequently formed to a single empyemic cavity. In uncomplicated cases the infection is purely pneumococcal and the organism may die, leaving a sterile pus. The treatment in such cases is simple and the prognosis good.

Conditions are very different when the infection of the pleura follows streptococcal pneumonia of either the interstitial or lobular types or a combination of the two. The pleural infection may then be massive at the start and may lead to abundant serous effusion before fibrinous agglutinations are possible. This leads to large empyemic cavities, in some instances including the greater part of the pleural cavity. Since these forms of pneumonia frequently involve both lungs, bilateral empyema is relatively common and almost invariably fatal when both sides are infected simultaneously.

A large part of the visceral pleura covers those portions of the lungs which bound the interlobar clefts. When infected, these portions of the pleura give rise to interlobar empyemata, which may be confined between the lobes by agglutinations or may communicate more or less freely with the rest of the pleural cavity. Confined interlobar empyemata offer greater difficulty to the diagnostician than do those which have the costal wall for one of their boundaries and are less accessible to surgical evacuation and to postoperative treatment. Even when the clefts are freely open, drainage and irrigation are rendered difficult.

Extensive thickening of the pleura bounding the interlobar clefts militates against expansion of the lung to meet the costal walls along these planes, and contact between the visceral and parietal pleuræ tends to be more imperfect along the lines of these clefts than in other parts of the cavity. Contraction of cicatricial tissue formed between the pulmonary lobes would draw the lung away from the costal wall. It is probable that a number of long, narrow, and persistent superficial sinuses that have proven refractory to treatment owe their origin to interlobar bands of cicatricial tissue which have held their walls apart at a time when an approximation would have been followed by obliteration through a union of granulations lining the lumen.

If an interlobar abscess, or a subpleural abscess within the lung, should rupture into the general pleural cavity a massive infection of the pleura would result, leading to the rapid development of a large exudate.

The infection of the pleura need not be of this massive character. Fibrinous agglutinations may confine the pus to certain localized areas, forming smaller empyema pockets. These may be coincidently or successively formed in various parts of the pleura, giving rise to the multiple pockets so frequently found at autopsy.

There is, however, another way in which multiple pockets may be formed. The prominence of productive inflammatory processes in the streptococcus infections of the bronchi and peribronchial tissues has already been referred to. A similar new formation of connective tissue takes place beneath the fibrinous deposit upon the pleural surfaces. If these pleural surfaces then come in contact for a sufficient period, the granulations on the two surfaces may

blend and give rise to permanent adhesions. This coalescence of the granulations upon opposed pleural surfaces is the natural way in which empyemic cavities become obliterated with permanent healing. This may lead also to the formation of separate pockets or to irregularly shaped cavities.

There is one circumstance possibly affecting the formation of multiple pockets to which reference has not been made. The changes in the bronchial and peribronchial tissues which are so prominent in the bronchopneumonia of interstitial type, often lead to a narrowing or partial stenosis of the bronchus, so that the accumulation of secretions blocks the passage of air. This is frequently followed by atelectasis of the corresponding portion of the lung, and insufflation of such a lung leaves these portions unexpanded. When the fluid is withdrawn these scattered areas of atelectasis prevent uniform expansion of the lung and a perfect apposition of the pleural surfaces, resulting in undrained pockets.

In contrast with the pneumococcus, the hemolytic streptococcus appears to call forth little if any active immunity. The bacteria may persist in an empyema cavity for many months, may infect the periosteum after rib resection, and, at times, they appear capable of lying dormant for a long period without exciting acute inflammation. These characteristics of streptococcus infections lead to chronicity and recrudescences after long intervals.

Experiments by Blake and Cecil [9] at the Army Medical School upon the production of pneumonia by intratracheal inoculation of minute quantities of virulent pneumococci showed very conclusively that the infection was disseminated through the interstitial tissues and that the pleura might be infected before marked consolidation of the lung took place. They also observed pericarditis and occasionally peritonitis as complicating infections, and in one or two instances noted an acute infection of the mediastinal tissues.

Since larger numbers of bacteria were required to produce infection in the monkey, infection with the hemolytic streptococcus appears to have been produced with more difficulty than infection with the pneumococcus. The lesions which were produced, however, were similar in character and distribution to those observed and described by MacCallum.

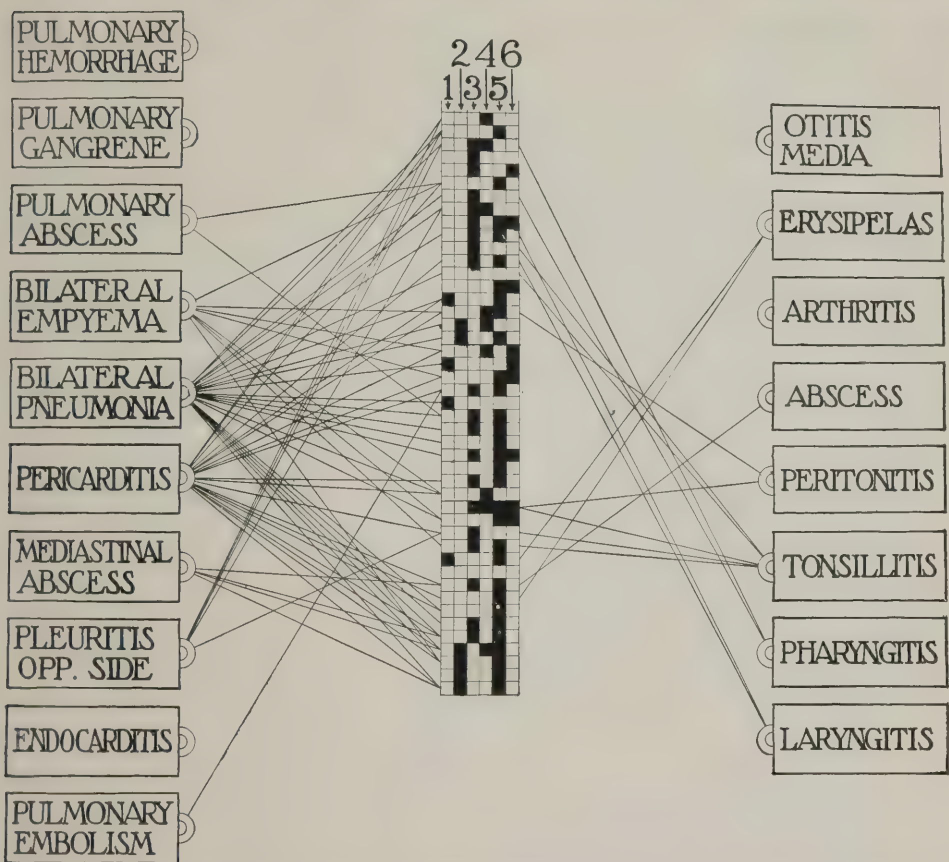
The special empyema records offer examples of most, if not all, of the conditions in the pleura and viscera which might be expected from the pathology of the different forms of pneumonia. There are few cases so completely described that it is possible to trace the course of events, step by step, from the first inception of disease to its termination. It would be impossible to give a detailed history of cases illustrating all of the numerous possibilities. These records, nevertheless, contain much information of value in the clinical care of empyema and call attention to the need of studying each case with respect to its individual peculiarities.

SERIOUS INFECTIONS COMPLICATING EMPYEMA.

From a clinical point of view the occurrence of serious infections complicating empyema is of importance. The development of pneumonia or of pleurisy on the opposite side, of pericarditis or of peritonitis not only affects the prognosis, but influences the judgment in regard to the treatment. In many of the fatal cases embodied in the special empyema records [1] autopsy has

revealed the presence of more than one of these concomitant infections. The records from Camp Dodge are numerous and particularly instructive in this respect. Charts LIV, LV, and LVI, have been prepared to set forth the relationships revealed by this single series of autopsies. The cases are represented in the central column by squares, six in each horizontal row representing a single case. The rows are arranged one beneath the other in chronological order

45 CASES OF EMPYEMA: DIED FIRST THREE DAYS



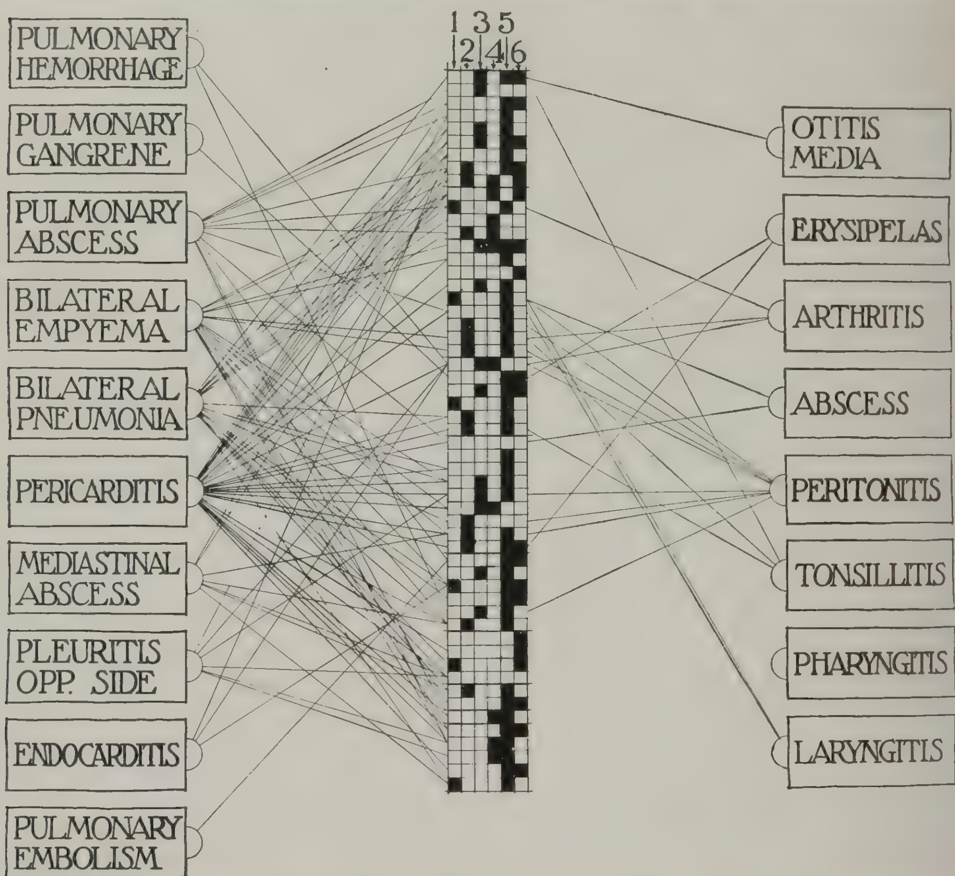
1-AFTER MEASLES; 2-AFTER INFLUENZA; 3-AFTER OTHER INFECTIONS
4-PNEUMOCOCCUS IN FLUID; 5 STREPTOCOCCUS IN FLUID; 6-OPERATED

CHART LIV.

in respect to the day of death after admission to the hospital. The superimposed squares form six columns indicating the preceding disease, the organism found in the pleural fluid, and whether or not a thoracotomy or costectomy had been done. To the left of this central column 10 serious intrathoracic conditions are represented and, to the right, eight of the more important extrathoracic conditions. From the central column, lines from the row of squares representing a given case connect it with the respective intra- or extrathoracic conditions found at autopsy in that particular case.

A mere glance at these diagrams suffices to show that very few cases of empyema at Camp Dodge died without one or more complicating conditions of a serious nature and that of these bilateral empyema or pneumonia, pericarditis and peritonitis were the most frequent. These complications are found irrespective of the lapse of time between admission to the hospital and death.

55 CASES OF EMPYEMA: DIED 4TH. TO 14TH. DAY



1-AFTER MEASLES; 2-AFTER INFLUENZA; 3-AFTER OTHER INFECTIONS
4 PNEUMOCOCCUS IN FLUID; 5-STREPTOCOCCUS IN FLUID; 6-OPERATED

CHART LV.

That the conditions favoring the development of the most important complicating localizations of infection shown in these diagrams were not confined to Camp Dodge is shown by the following tabulation of 603 autopsies. In this tabulation the cases are grouped according to the time of death after the recognition of pneumonia and not, as in the preceding diagrams, after admission to the hospital. This furnished a more uniform grouping, since some of the cases were admitted for diseases having no direct bearing on the development of empyema. The cases at Camp Dodge are included in this series. It is obvious from the figures that many of these cases must have presented

more than one such complicating localization of the infection, but it has not appeared necessary to trace these coincidences further than was done in preparing the diagrams for Camp Dodge.

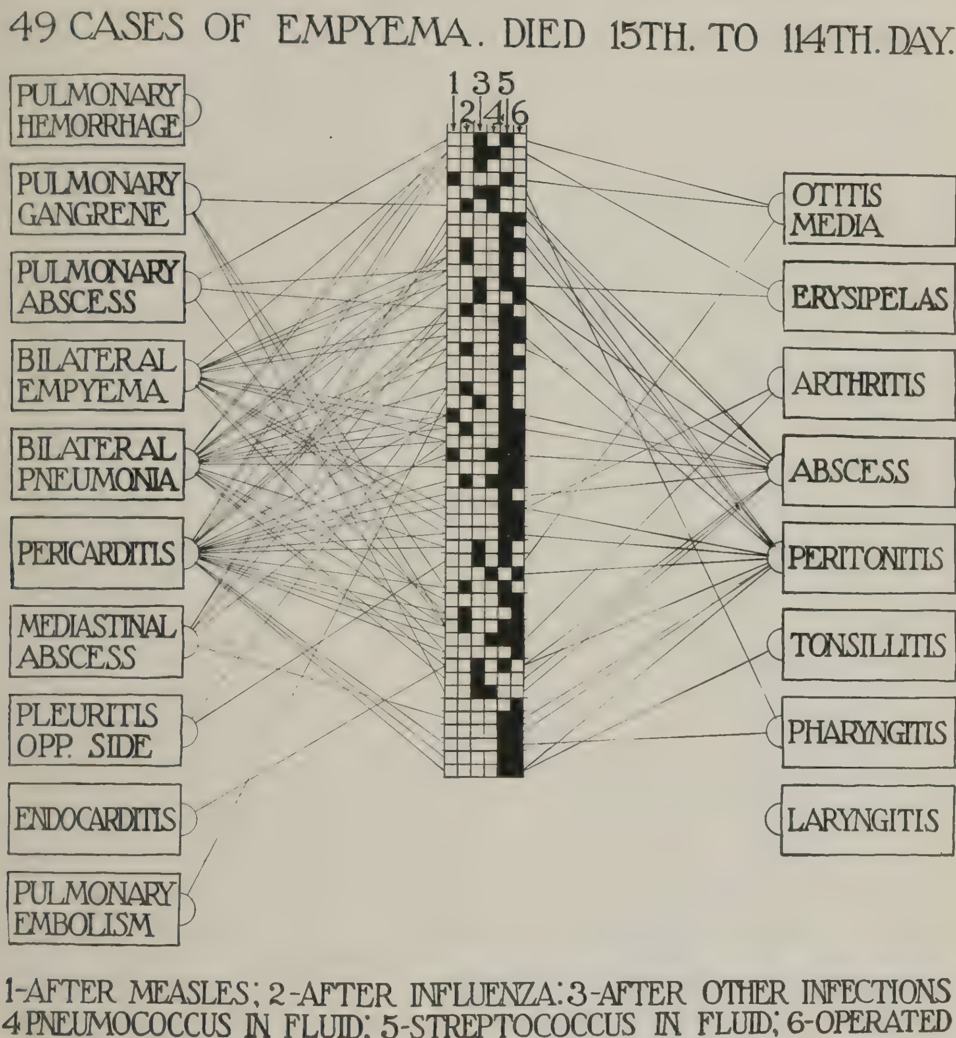


CHART LVI.

TABLE 31.[a] —*Chief complications of empyema found at autopsy in the United States Army camps during 1917–18.*

Death after pneumonia.	Bilateral empyema.	Bilateral empyema percentage.	Bilateral pneumonia.	Bilateral pneumonia percentage.	Pericarditis.	Pericarditis percentage.	Peritonitis.	Peritonitis percentage.	Mediastinal abscess.	Mediastinal abscess percentage.	Total number of autopsies.
0 days	3	43	5	71	0	0	2	3	0	0	7
1-4 days	21	31	36	53	23	34	15	22	1	1.47	68
4-7 days	22	33	36	55	22	33	12	18	4	6.06	66
7-14 days	50	38	93	71	54	41	22	17	5	3.82	131
14-21 days	39	44	64	72	32	36	20	22	4	4.49	89
21-28 days	28	55	38	75	24	47	12	24	3	5.90	51
28-35 days	34	56	33	54	41	67	11	18	2	3.28	61
35-42 days	13	41	20	63	23	72	6	19	2	6.25	32
42+ days	43	44	36	37	44	45	26	26	3	3.06	98
Total	253	42	361	60	263	44	126	21	24	4	603

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

The significance of the figures in this table is made more evident when they are plotted. Chart LVII, in which the curves represent the percentages of bilateral pneumonia, bilateral empyema, pericarditis and peritonitis, shows that in fatal cases each of these conditions is found in a considerable proportion of the total; that the possibilities of bilateral pneumonia at autopsy are highest up to the conclusion of the fourth week and are never absent; that empyema on the opposite side is at a maximum toward the sixth week after the primary pneumonia; that pericarditis, which is usually fatal shortly after its occurrence, is a complication that may occur in a large percentage of the fatal cases at any time soon after the development of pneumonia, but more frequently between

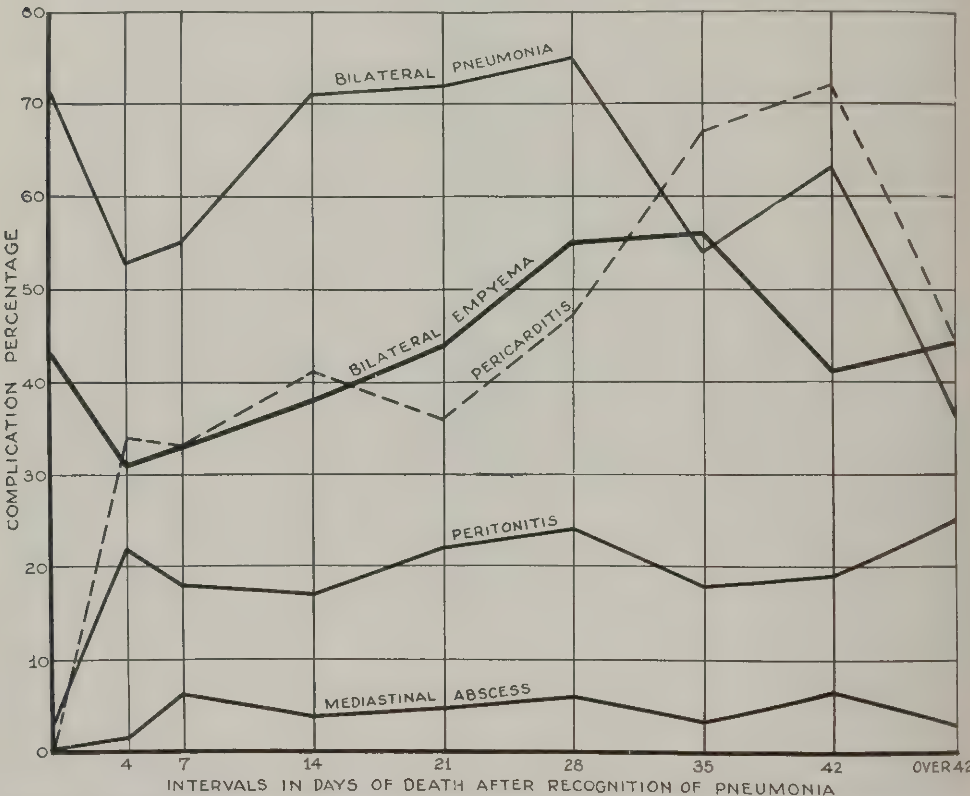


CHART LVII.—Chief complications of empyema found at autopsy. Charted according to intervals after the onset of the infection.

the 5th and 7th week, and that peritonitis claims a fairly uniform number of victims at all times. The curve of mediastinal abscess includes only cases in which suppuration in the mediastinum was definitely described. There are instances in which edema of the mediastinal tissues was noted at autopsy and at least one in which cultures from this serous fluid contained hemolytic streptococci. In this case there was bilateral empyema, but neither pericarditis nor peritonitis.

The clinical significance of these complications is evident. For several weeks after the onset of a pneumonia with unilateral empyema the possibility that one or more of these complications may take place should be borne in mind. This affects not only the prognosis but the opinion of the surgeon

as to the appropriate measures to be adopted in treatment. It is to be noted that about four-fifths of the fatal cases in which bacterial data are available were associated with a streptococcus and that among these the hemolytic streptococcus predominated. It appears, then, that caution in treatment and prognosis is particularly important in cases of streptococcal infection. This is a necessary corollary of the pathology of the pneumonias due to this organism. Cases of pneumococcus infection are not without similar dangers though of minor degree.

An inquiry concerning the microorganisms associated with these cases results in the figures given in Table 32. All the cases in which the streptococcus was found, whether alone or associated with the pneumococcus, are grouped in one class, those in which a pneumococcus alone occurred in a second class, and the staphylococcus in a third, the total of these three classes being the positive findings. The percentages of each class corresponds very closely to the results obtained from a similar analysis of the bacteriological results in pleural exudates, as shown in Table 4 (vide Chapter II, p. 55). A single case of tuberculous pleurisy has been omitted from the table.

TABLE 32.[a]—*Three chief groups of organisms in 450 fatal cases of empyema.*

Death after pneumonia.	Streptococcus group.	Streptococcus percentage.	Pneumococcus group.	Pneumococcus percentage.	Staphylococcus group.	Staphylococcus percentage.	Total cases.
0 days	3	60	2	40	0	0	5
1-4 days	56	98	0	0	1	2	57
4-7 days	40	74	14	26	0	0	54
7-14 days	84	82	13	13	4	4	101
14-21 days	53	84	9	14	0	0	62
21-28 days	27	77	6	17	2	6	35
28-35 days	34	77	10	23	0	0	44
35-42 days	16	69	6	26	1	5	23
42+days	50	72	16	23	3	5	69
Total	363	81	76	17	11	2	450

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

In the early stages of exudation the pleural fluid in streptococcus empyema is serous, straw colored, tawny, or pinkish from admixture with blood pigment, and often slightly fluorescent, appearing brownish by transmitted light and yellowish-green by reflected light. Occasionally it appears quite clear but is usually somewhat cloudy owing to enormous numbers of microorganisms. These may be so numerous that a plate culture made from a single loopful contains half a million or more colonies, visible only under the microscope. A spontaneous coagulation of these serous fluids after their withdrawal has occasionally been observed.

The amount of serous exudate formed within a few hours may be very large. Many cases are on record in which the first aspiration yielded two or more liters, and as much as 4 or even 6 liters have been noted as obtained at a single aspiration. Measurements of fluid withdrawn at daily intervals show that the accumulation may frequently reach a liter a day.

The serous character of the exudate is maintained for only a short time: within from one to three days fibrin and leucocytes appear in such quantity that on standing a sediment is formed amounting to from one-tenth to one-fifth of the total volume. The supernatent fluid is yellow, brownish, or light

pink in color. At this time the pleural surfaces are covered with a deposit of fibrin, often of some thickness and sometimes interfering with aspiration. The fibrin soon becomes abundantly infiltrated with leucocytes and the fluid progressively more charged with these cells, becoming seropurulent and then purulent, until finally only a thin layer of clear serum appears at the top after the fluid has stood for many hours.

This description is based upon cases in which the empyema is due to the hemolytic streptococcus. Smears of the fluid, however, rarely reveal this organism in chains of any considerable length. Usually they appear as diplococci with the adjacent surfaces slightly flattened. From two to six of these may lie in a row forming very short streptococcal chains, but in view of the great number of isolated diplococci it is often difficult for the observer to convince himself that this arrangement may not be accidental. When cultivated in broth long chains develop. Very rarely chains of 80 or more diplococcal forms are found in the original freshly withdrawn exudate.

The occurrence of phagocytosis in the exudate is variable. In some cases it appears to be almost entirely absent, but in other cases it is marked and cells crowded with microorganisms are frequently seen. In some instances failure of the cell nuclei to stain as deeply in these cells as in neighboring leucocytes, while the organisms themselves stain deeply, gives the impression that the phagocytosis is not an effective protection against this infection; but in other instances the reverse is observed, the microorganisms within the cell taking the stain but faintly while the nuclei appear normal in this and other respects. In the majority of the leucocytes the nuclei are fragmented, from four to six clumps of nuclear material lying separated within the cytoplasm.

DISSEMINATION OF INFECTION IN SURVIVING CASES.

That the dissemination of the infection in surviving cases was less extensive than in fatal cases is shown by the relatively small number in which the intrathoracic condition was bilateral, notwithstanding the fact that bronchopneumonia was prone to affect both lungs. Peritonitis is mentioned in only two cases which recovered. In one of these an investigation showed that the reported peritonitis was based on the following brief clinical memorandum made on the 835th day after admission to the hospital for a lobar pneumonia of the right lower lobe: "Local peritonitis over region of right kidney, symptoms of subphrenic abscess." The day before, this localized cavity had been drained by resecting a callus formed after the first resection of the eighth rib in the midaxillary line three months previously. The case offers no analogy to the acute general peritonitis so frequent in fatal cases. No details are available concerning the character of the other case in which peritonitis was noted, and the patient recovered.

Pericarditis has also been of low incidence in cases that survived. The diagnosis has usually been based upon the occurrence of a friction sound referred to the pericardium. In cases of pericarditis which subdivided, fibrous agglutination and ultimate adhesions sometimes resulted. A true infection of the pericardium, with abundant purulent exudate due to the streptococcus, was almost invariably fatal.

With respect to the extrathoracic infections, other than peritonitis and meningitis, there is but little percentage difference in incidence between cases that survived and those proving fatal.

Confining the compilation to data from camp base hospitals and excluding the chronic cases transferred from other hospitals, the occurrence of the most frequent infections complicating empyema is given in Tables 33, 34, and 35. These summaries are based upon the special emypema records and show the frequency of these complications as noted in those records in both fatal and surviving cases. Both the absolute numbers and percentages are given.

Nearly all of the cases of empyema in the Army that were recognized and survived received active treatment. This treatment varied from a single aspiration to extensive operations entailing decortication of the lung and collapse of the chest wall. It is therefore impossible to describe the course that would have been taken by the infection of the pleura had there been no surgical intervention. There are no records of autopsies made upon cases any considerable time after healing of the empyema. A knowledge of the ultimate results of empyema in the Army is dependent, therefore, upon the personal reports of the patients and on the results of physical and X-ray examinations. Since the character of these findings was determined by both the pathology and the treatment of each case, a consideration of the kinds and degrees of disability experienced by the patients with their probable explanations can best be deferred until the methods of treatment have been described. But there are certain pathological processes which must influence the ultimate outcome in every case. For example, it is evident that productive inflammatory processes must follow the damage wrought by the infections described in this chapter and that these will inevitably lead to the formation of cicatricial tissue tending to contract. Thus, adhesions and deformities are threatened in proportion to the extent and abundance of the granulation tissue within the lung or upon the pleural surfaces. Analogous to this is the new formation of bone from surviving periosteal tissues.

It should be the aim of the surgeon to first avert conditions threatening life, then to promote the well-being of his patient, and, finally, to reduce the ultimate disability to a minimum.

TABLE 33.[a]—*Association of the three chief classes of infecting organisms found in the pleural exudate with the more frequent complications—Based on 3,889 cases.*

Line numbers.	Complications.	Bacteriology given.												Bacteriology unknown.			Grand total.		
		Streptococcus.			Pneumococcus.			Staphylococcus.			Totals.								
		Lived.	Died.	Total.	Lived.	Died.	Total.	Lived.	Died.	Total.	Lived.	Died.	Total.	Lived.	Died.	Total.	Lived.	Died.	Total.
1	Bilateral pneumonia	285	314	599	151	75	226	13	13	26	449	402	851	135	167	302	584	569	1,153
	Per cent			70.4			26.6			3.1			73.8			26.2			29.64
2	Pulmonary abscess	56	68	124	40	9	29	5	0	5	81	77	158	17	22	39	98	99	197
	Per cent			78.5			18.4			3.2			80.2			19.8			5.07
3	Mediastinal infection	0	44	44	0	3	3	0	0	0	0	47	47	0	7	7	0	54	54
	Per cent			93.6			6.4			0.0			87.0			13.0			1.40
4	Pericarditis	23	175	198	9	25	34	1	2	3	33	202	235	6	33	39	39	235	274
	Per cent			84.2			14.5			1.3			85.8			14.2			7.05
5	Endocarditis	0	13	13	0	0	0	0	0	0	0	13	13	0	6	6	0	19	19
	Per cent			100			0.0			0.0			68.4			31.6			0.49
6	Peritonitis	1	85	86	2	9	11	0	1	1	3	95	98	0	13	13	3	108	111
	Per cent			87.8			11.2			1.0			88.3			11.7			2.85
7	Abscess of soft parts	67	38	105	35	3	38	4	1	5	106	42	148	20	6	26	126	48	174
	Per cent			70.9			25.7			3.4			85.1			14.9			4.47
8	Phlebitis	6	4	10	5	0	5	2	0	2	13	4	17	2	2	4	15	6	21
	Per cent			58.8			29.4			11.8			81.0			19.0			0.54
9	Erysipelas	12	17	29	5	2	7	0	0	0	17	19	36	5	5	10	22	24	46
	Per cent			80.6			19.4			0.0			78.3			21.7			1.18
10	Arthritis	18	14	32	9	1	10	1	0	1	28	15	43	16	2	18	44	17	61
	Per cent			74.4			23.3			2.3			70.5			29.5			1.57
11	Otitis media	61	32	93	33	2	35	1	1	2	95	35	130	16	5	21	111	40	151
	Per cent			71.5			26.9			1.5			86.1			13.9			3.88
12	Mastoiditis	9	9	18	4	1	5	1	1	2	14	11	25	4	0	4	18	11	29
	Per cent			72.0			20.0			8.0			86.2			13.8			0.75
13	Meningitis	0	6	6	0	5	5	0	1	1	0	12	12	0	3	3	0	15	15
	Per cent			50.0			41.7			8.3			80.0			20.0			0.39
14	Empyema, right side	658	277	935	325	62	387	27	7	34	1,010	346	1,356	369	169	538	1,379	515	1,894
	Per cent			69.0			28.5			2.5			71.6			28.4			48.7
15	Empyema, left side	608	250	858	275	45	320	23	10	33	906	305	1,211	308	149	457	1,214	454	1,668
	Per cent			70.9			26.4			2.7			72.6			27.4			42.9
16	Bilateral empyema	19	166	185	12	47	59	0	9	9	31	222	253	5	69	74	36	291	327
	Per cent			73.1			23.3			3.6			77.4			22.6			8.41

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

TABLE 34.[a]—*Table of complications, with case mortalities.*[b]

Total cases, 3,889.		Total cases, 3,889.		Died, 1,260 (32.4%).													Lived, 2,629 (67.6%).											
Line numbers.		Column numbers.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		Complications.	Cases.	Bilateral pneumonia.	Pulmonary abscess.	Mediastinal infection.	Pericarditis.	Endocarditis.	Peritonitis.	Abscess of soft parts.	Phlebitis.	Erysipelas.	Arthritis.	Otitis media.	Mastoiditis.	Meningitis.	Empyema, right side. 1,379 (52.5%). S	p	Sa	?	Empyema, left side. 1,214 (46.2%). S	p	Sa	?	Bilateral empyema. 36 (1.4%). S	p	Sa	?
				569 45.2%	99 7.9%	54 4.3%	235 18.7%	19 1.5%	108 8.6%	48 3.8%	6 0.5%	24 1.9%	17 1.3%	40 3.2%	11 0.9%	15 1.2%	658 47.7%	325 23.5%	27 2.0%	369 26.8%	608 50.1%	275 22.7%	23 1.9%	308 25.4%	19 52.8%	12 33.3%	0 0.0%	5 13.9%
1	Lived, 2,629 (67.6%).	Bilateral pneumonia	584 22.2%	49.1% / 50.6%	44 61.7%	50 100%	186 93.9%	13 100%	76 100%	28 50.9%	5 55.6%	16 100%	10 40.0%	24 49.0%	4 50.0%	7 100%	140 57.6%	69 74.2%	10 76.9%	89 50.7%	131 57.5%	72 82.8%	3 50.0%	62 52.1%	14 10.9%	10 21.7%	0 0.0%	4 8.5%
2		Pulmonary abscess	98 3.7%	24 35.4%	50.3% / 49.7%	6 100%	17 89.5%	2 100%	7 100%	6 60.0%	0 0.0%	1 100%	1 33.3%	3 37.5%	1 100%	2 100%	32 55.2%	14 82.4%	4 100%	12 57.1%	24 52.2%	5 83.3%	1 100%	5 71.5%	0 0.0%	1 16.7%	0 0.0%	0 0.0%
3		Mediastinal infection	0 0.0%	0 0.0%	0 0.0%	100% / 0.0%	27 100%	0 0.0%	8 100%	5 100%	0 0.0%	0 0.0%	4 100%	1 100%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
4		Pericarditis	39 1.5%	12 6.1%	2 10.5%	0 0.0%	88.8% / 11.2%	5 100%	28 100%	7 87.5%	0 0.0%	3 100%	3 100%	8 72.7%	4 100%	1 100%	7 15.9%	3 30.0%	0 0.0%	3 23.1%	15 23.8%	6 60.0%	1 100%	3 25.0%	1 1.1%	0 0.0%	0 0.0%	0 0.0%
5		Endocarditis	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	100% / 0.0%	1 100%	3 100%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
6		Peritonitis	3 0.1%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	97.3% / 2.7%	5 83.3%	0 0.0%	0 0.0%	1 100%	2 100%	1 100%	1 100%	1 4.5%	1 50.0%	0 0.0%	0 0.0%	0 0.0%	1 25.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
7		Abscess of soft parts	126 4.8%	27 49.1%	4 40.0%	0 0.0%	1 12.5%	0 0.0%	1 16.7%	27.6% / 72.4%	0 0.0%	1 20.0%	2 25.0%	4 28.6%	2 100%	0 0.0%	41 71.9%	23 100%	3 100%	11 73.3%	25 71.4%	12 85.7%	1 50.0%	9 90.0%	1 7.7%	0 0.0%	0 0.0%	0 0.0%
8		Phlebitis	15 0.6%	4 44.4%	1 100%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100%	28.6% / 71.4%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	5 100%	3 100%	0 0.0%	1 33.3%	0 0.0%	2 100%	2 100%	1 100%	1 33.3%	0 0.0%	0 0.0%	0 0.0%
9		Erysipelas	22 0.8%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	4 80.0%	0 0.0%	52.3% / 47.7%	0 0.0%	1 33.3%	0 0.0%	0 0.0%	6 40.0%	1 33.3%	0 0.0%	3 50.0%	5 50.0%	3 100%	0 0.0%	2 50.0%	1 25.0%	1 100%	0 0.0%	0 0.0%
10		Arthritis	44 1.7%	15 60.0%	2 66.7%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	6 75.0%	2 100%	0 0.0%	27.9% / 72.1%	1 33.3%	1 100%	0 0.0%	8 80.0%	4 100%	0 0.0%	3 100%	10 66.7%	3 75.0%	1 100%	9 100%	0 0.0%	2 100%	0 0.0%	1 33.3%
11		Otitis media	111 4.2%	25 51.0%	5 62.5%	0 0.0%	3 27.3%	0 0.0%	0 0.0%	10 71.4%	0 0.0%	2 66.7%	2 66.7%	[illegible]	0 0.0%	0 0.0%	28 66.7%	16 94.1%	1 100%	10 83.3%	31 70.5%	16 94.1%	0 0.0%	6 85.7%	2 28.6%	1 100%	0 0.0%	0 0.0%
12		Mastoiditis	18 0.7%	4 50.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	37.9% / 62.1%	1 100%	4 44.4%	2 100%	0 0.0%	2 100%	5 83.3%	2 66.7%	1 50.0%	2 100%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
13		Meningitis	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	100% / 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
14	Died, 1,260 (32.4%). Empyema, right side. 515 (40.9%).	S	277 53.8%	103 42.4%	26 44.8%	3 100%	37 84.1%	5 100%	21 95.5%	16 28.1%	0 0.0%	9 60.0%	2 20.0%	14 33.3%	5 55.6%	1 100%	70.4% / 29.6%											
15		p	62 12.0%	24 25.9%	3 17.6%	2 100%	7 70.0%	0 0.0%	1 50.0%	0 0.0%	0 0.0%	2 66.7%	0 0.0%	1 5.9%	0 0.0%	2 100%		84.0% / 16.0%										
16		Sa	7 1.4%	3 23.1%	0 0.0%	0 0.0%	1 100%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%			79.1% / 20.9%									
17		?	169 32.8%	67 49.3%	9 42.9%	1 100%	10 76.9%	1 100%	5 100%	4 26.7%	2 66.7%	3 50.0%	0 0.0%	2 16.7%	0 0.0%	2 100%				68.6% / 31.4%								
18	Empyema, left side. 454 (36.0%).	S	250 55.1%	97 42.5%	22 47.8%	10 100%	48 76.1%	2 100%	26 100%	10 28.6%	2 100%	5 50.0%	5 33.3%	13 29.5%	1 16.7%	2 100%					70.9% / 29.1%							
19		p	45 9.9%	15 17.2%	1 16.7%	1 100%	4 40.0%	0 0.0%	3 75.0%	2 14.3%	0 0.0%	0 0.0%	1 25.0%	1 5.9%	1 33.3%	1 100%						85.8% / 14.1%						
20		Sa	10 2.2%	3 50.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100%	1 50.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 50.0%	1 100%							69.7% / 30.3%					
21		?	149 32.8%	57 47.9%	2 28.5%	1 100%	9 75.0%	2 100%	3 100%	1 16.0%	0 0.0%	2 50.0%	0 0.0%	1 14.3%	0 0.0%	0 0.0%								67.4% / 32.6%				
22	Bilateral empyema. 291 (23.1%).	S	166 57.0%	114 89.1%	20 100%	28 100%	90 98.9%	6 100%	38 100%	12 92.3%	2 66.7%	3 75.0%	7 100%	5 71.4%	3 100%	3 100%									10.3% / 89.7%			
23		p	47 16.2%	36 78.3%	5 83.3%	0 0.0%	14 100%	0 0.0%	3 100%	1 100%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	2 100%										20.3% / 79.7%		
24		Sa	9 3.1%	7 100%	0 0.0%	0 0.0%	4 100%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100%	0 0.0%	0 0.0%											0.0% / 100%	
25		?	69 23.7%	43 91.5%	11 100%	5 100%	14 100%	3 100%	5 100%	1 100%	0 0.0%	0 0.0%	2 66.7%	2 100%	0 0.0%	1 100%												6.8% / 93.2%

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

[b] For convenience the table has been divided into four large squares and subdivided again diagonally. The diagonal line separates the living from the dead, as has been indicated in the outer margins. This table may be used for the following correlations: (1) To determine the percentage and the number of cases among the living and the dead which were associated with any of the various complications. For example, in the upper left-hand margins under "Phlebitis" of 1,260 cases of empyema dying, 6, or 0.5 per cent, were associated with this complication, while of 2,629 living cases, 15, or 0.6 per cent, had a similar complication. (2) To determine the mortality of cases with two associated conditions. For example, at the intersection of column 1 and line 8, below the diagonal line in the upper left-hand square, the figure 4 indicates that four of the living cases showed this association of the complications indicated as complications. The percentage figure shows the percentage of the entire number of cases showing this association which lived. The intersection of the similar columns above the diagonal line indicates the number of cases, with these two associated conditions, which died, as well as the percentage mortality in cases of empyema associated with the two conditions indicated in the margins of the intersecting columns. (3) To determine the relationship of the type of empyema, whether right, left, or bilateral, the associated organism and the indicated complication. The intersecting squares give the number of cases falling in each category and the percentage mortality and the percentage of living cases. (4) To determine the total mortality according to the association of the conditions indicated in the margins of the intersecting columns. These percentages are given immediately above and below the heavy diagonal line at the intersection of similar columns.

TABLE 35.[a]—*Table of complications, with relative frequencies.*

Total cases, 3,889. Died, 1,260 (columns 1–13). Lived, 2,629 (columns 14–25).

Line numbers	Complications	Cases	1 Bilateral pneumonia.	2 Pulmonary abscess.	3 Mediastinal infection.	4 Pericarditis.	5 Endocarditis.	6 Peritonitis.	7 Abscess of soft parts.	8 Phlebitis.	9 Erysipelas.	10 Arthritis.	11 Otitis media.	12 Mastoiditis.	13 Meningitis.
			569	99	54	235	19	108	48	6	24	17	40	11	15
Lived, 2,629.															
1	Bilateral pneumonia	584	45.2% 22.2%	44 44.4%	50 92.6%	186 79.2%	13 68.4%	76 70.3%	28 58.3%	5 83.3%	16 66.7%	10 58.8%	24 60.0%	4 36.4%	7 46.7%
2	Pulmonary abscess	98	24 24.5%	7.9% 3.7%	6 11.1%	17 7.2%	2 10.5%	7 6.5%	6 12.5%	0 0.0%	1 4.2%	1 5.9%	3 7.5%	1 9.1%	2 13.3%
3	Mediastinal infection	0	0 0.0%	0 0.0%	4.3% 0.0%	27 11.5%	0 0.0%	8 7.4%	5 10.4%	0 0.0%	0 0.0%	4 23.5%	1 2.5%	0 0.0%	0 0.0%
4	Pericarditis	39	12 30.8%	2 5.1%	0 0.0%	18.7% 1.5%	5 26.3%	28 25.9%	7 14.6%	0 0.0%	3 12.5%	3 17.6%	8 20.0%	4 36.4%	1 6.7%
5	Endocarditis	0	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1.5% 0.0%	1 0.9%	3 6.25%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 6.7%
6	Peritonitis	3	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	8.6% 0.1%	5 10.4%	0 0.0%	0 0.0%	1 5.9%	2 5.0%	1 9.1%	1 6.7%
7	Abscess of soft parts	126	27 21.4%	4 3.2%	0 0.0%	1 0.8%	0 0.0%	1 0.8%	3.8% 4.8%	0 0.0%	1 4.2%	2 11.8%	4 10.0%	2 18.2%	0 0.0%
8	Phlebitis	15	4 26.7%	1 6.7%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 6.7%	0.5% 0.6%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
9	Erysipelas	22	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	4 18.2%	0 0.0%	1.9% 0.8%	0 0.0%	1 2.5%	0 0.0%	0 0.0%
10	Arthritis	44	15 34.1%	2 4.5%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	6 13.6%	2 4.5%	0 0.0%	1.3% 1.7%	1 2.5%	1 9.1%	0 0.0%
11	Otitis media	111	25 22.5%	5 4.5%	0 0.0%	3 2.7%	0 0.0%	0 0.0%	10 9.0%	0 0.0%	2 1.8%	2 1.8%	3.2% 4.2%	0 0.0%	0 0.0%
12	Mastoiditis	18	4 22.2%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0.9% 0.7%	1 6.7%
13	Meningitis	0	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1.2% 0.0%
Died, 1,260.															
14	Empyema, right side. 515 — S	277	103 37.2%	26 9.4%	6 2.2%	37 13.4%	5 1.8%	21 7.6%	16 5.8%	0 0.0%	9 3.2%	2 0.7%	14 5.1%	5 1.8%	1 0.4%
15	p	62	24 38.7%	3 4.8%	2 3.2%	7 11.3%	0 0.0%	1 1.6%	0 0.0%	0 0.0%	2 3.2%	0 0.0%	1 1.6%	0 0.0%	2 3.2%
16	Sa	7	3 42.9%	0 0.0%	0 0.0%	1 14.3%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
17	?	169	67 39.6%	9 5.3%	1 0.6%	10 5.9%	1 0.6%	5 3.0%	4 2.4%	2 1.2%	3 1.8%	0 0.0%	2 1.2%	0 0.0%	2 1.2%
18	Empyema, left side. 454 — S	250	97 38.8%	22 8.8%	10 4.0%	48 19.2%	2 0.8%	26 10.4%	10 4.0%	2 0.8%	5 2.0%	5 2.0%	13 5.2%	1 0.4%	2 0.8%
19	p	45	15 33.3%	1 2.2%	1 2.2%	4 8.9%	0 0.0%	3 6.7%	2 4.4%	0 0.0%	0 0.0%	1 2.2%	1 2.2%	1 2.2%	1 2.2%
20	Sa	10	3 30.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 10.0%	1 10.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 10.0%	1 10.0%
21	?	149	57 38.3%	2 1.3%	1 0.7%	9 6.0	2 1.3%	3 2.0%	1 0.7%	0 0.0%	2 1.3%	0 0.0%	1 0.7%	0 0.0%	0 0.0%
22	Bilateral empyema. 291 — S	166	114 68.7%	20 12.0%	28 16.9%	90 54.2%	6 3.6%	38 22.9%	12 7.2%	2 1.2%	5 3.0%	7 4.2%	5 3.0%	3 1.8%	3 1.8%
23	p	47	36 76.6%	5 10.6%	0 0.0	14 29.8%	0 0.0%	5 10.6%	1 2.1%	0 0.0%	0 0.0%	0 0.0%	0 0.0	0 0.0%	2 4.3%
24	Sa	9	7 77.8%	0 0.0%	0 0.0	1 11.1%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 11.1%	0 0.0%	0 0.0%
25	?	69	43 62.3%	11 15.9%	5 7.2%	14 20.3%	3 4.3%	5 7.2%	1 1.5%	0 0.0%	0 0.0%	2 2.9%	2 2.9%	0 0.0%	1 1.5%

Line numbers	Complications	Cases	14 Empyema, right side, 1,379: S	15 p	16 Sa	17 ?	18 Empyema, left side, 1,214: S	19 p	20 Sa	21 ?	22 Bilateral empyema, 36: S	23 p	24 Sa	25 ?
			658	325	27	369	608	275	23	308	19	12	0	5
Lived, 2,629.														
1	Bilateral pneumonia	584	140 21.3%	69 21.2%	10 37.0%	69 18.7%	131 21.5%	72 26.2%	3 13.0%	62 20.1%	14 73.7%	10 83.3%	0 0.0%	4 80.0%
2	Pulmonary abscess	98	32 4.9%	14 4.3%	4 14.8%	12 3.3%	24 3.9%	5 1.8%	1 4.3%	5 1.6%	0 0.0%	1 8.3%	0 0.0%	0 0.0%
3	Mediastinal infection	0	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
4	Pericarditis	39	7 1.1%	3 0.9%	0 0.0%	3 0.8%	15 2.5%	6 2.2%	1 4.3%	3 1.0%	1 5.3%	0 0.0%	0 0.0%	0 0.0%
5	Endocarditis	0	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
6	Peritonitis	3	1 0.2%	1 0.3%	0 0.0%	0 0.0%	0 0.0%	1 0.4%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
7	Abscess of soft parts	126	41 6.2%	23 7.1%	3 11.1%	11 3.0%	25 4.1%	12 4.4%	1 4.3%	9 2.9%	1 5.3%	0 0.0%	0 0.0%	0 0.0%
8	Phlebitis	15	5 0.8%	3 0.9%	0 0.0%	1 0.3%	0 0.0%	2 0.7%	2 8.7%	1 0.3%	1 5.3%	0 0.0%	0 0.0%	0 0.0%
9	Erysipelas	22	6 0.9%	1 0.3%	0 0.0%	3 0.8%	5 0.8%	3 1.1%	0 0.0%	2 0.6%	1 5.3%	1 8.3%	0 0.0%	0 0.0%
10	Arthritis	44	8 1.2%	4 1.2%	0 0.0%	6 1.6%	10 1.6%	3 1.1%	1 4.3%	9 2.9%	0 0.0%	2 16.7%	0 0.0%	1 20.0%
11	Otitis media	111	29 4.3%	16 4.9%	1 3.7%	10 2.7%	31 5.1%	16 5.8%	0 0.0%	6 1.9%	2 10.5%	1 8.3%	0 0.0%	0 0.0%
12	Mastoiditis	18	4 0.6%	2 0.6%	0 0.0%	2 0.5%	5 0.8%	2 0.7%	1 4.3%	2 0.6%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
13	Meningitis	0	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%
Died, 1,260.														
14	Empyema, right side. 515 — S	277	47.7% 53.8%											
15	p	62		23.5% 12.0%										
16	Sa	7			2.0% 1.4%									
17	?	169				26.8% 32.8%								
18	Empyema, left side. 454 — S	250					50.1% 55.1%							
19	p	45						22.7% 9.9%						
20	Sa	10							1.9% 2.2%					
21	?	149								25.4% 32.8%				
22	Bilateral empyema. 291 — S	166									52.8% 57.0%			
23	p	47										33.3% 16.2%		
24	Sa	9											0.0% 3.1%	
25	?	69												13.9% 23.7%

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

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(5) Opie, L. E., Blake, F. G., Small, J. C., and Rivers, R. M.: Op. cit., 239 et seq.

(6) MacCallum, W. G.: Op. cit., 136, 137.

(7) Ibid., 71.

(8) Ibid., 93.

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CHAPTER IV.

TREATMENT OF EMPYEMA CAVITIES WITH ANTISEPTIC SOLUTIONS.

SOLUTIONS EMPLOYED.

Records of the experiences in the use of antiseptics in the treatment of empyema form one of the most interesting and valuable chapters in the history of this disease. There are few topics about which there have been such diversities of opinion. Many of the divergent views concerning the efficacy of antiseptics have been due to differences in the pathological conditions presented by the cases, in the choice of the antiseptic, and in the technical details of its application.

The antiseptic most frequently used was Dakin's neutral solution of sodium hypochlorite. A careful review of the special empyema records reveals 1,774 cases in which it was employed. These cases, however, do not form a homogeneous group. In some, this antiseptic was used only after the case had become chronic. In others, it was applied immediately after operation and used persistently until the wound closed. The mode of application was not uniform. There were cases in which the Carrel technique was carefully followed in detail, the wounds were irrigated daily at the time dressings were renewed, and Carrel tubes were inserted in all parts of the cavity. This technique permitted the instillation of the solution at intervals of from one to four hours, during the day and night, until the dressings were renewed on the following day. In other cases these frequent instillations were omitted and the application of the solution consisted only in a daily irrigation when the cases were dressed. In a relatively small number of cases there was an alternate application of Dakin's solution and some other antiseptic, either dichloramine–T or formalin. These divergencies in the time and method of using the antiseptic render the task of estimating its exact value one of considerable difficulty.

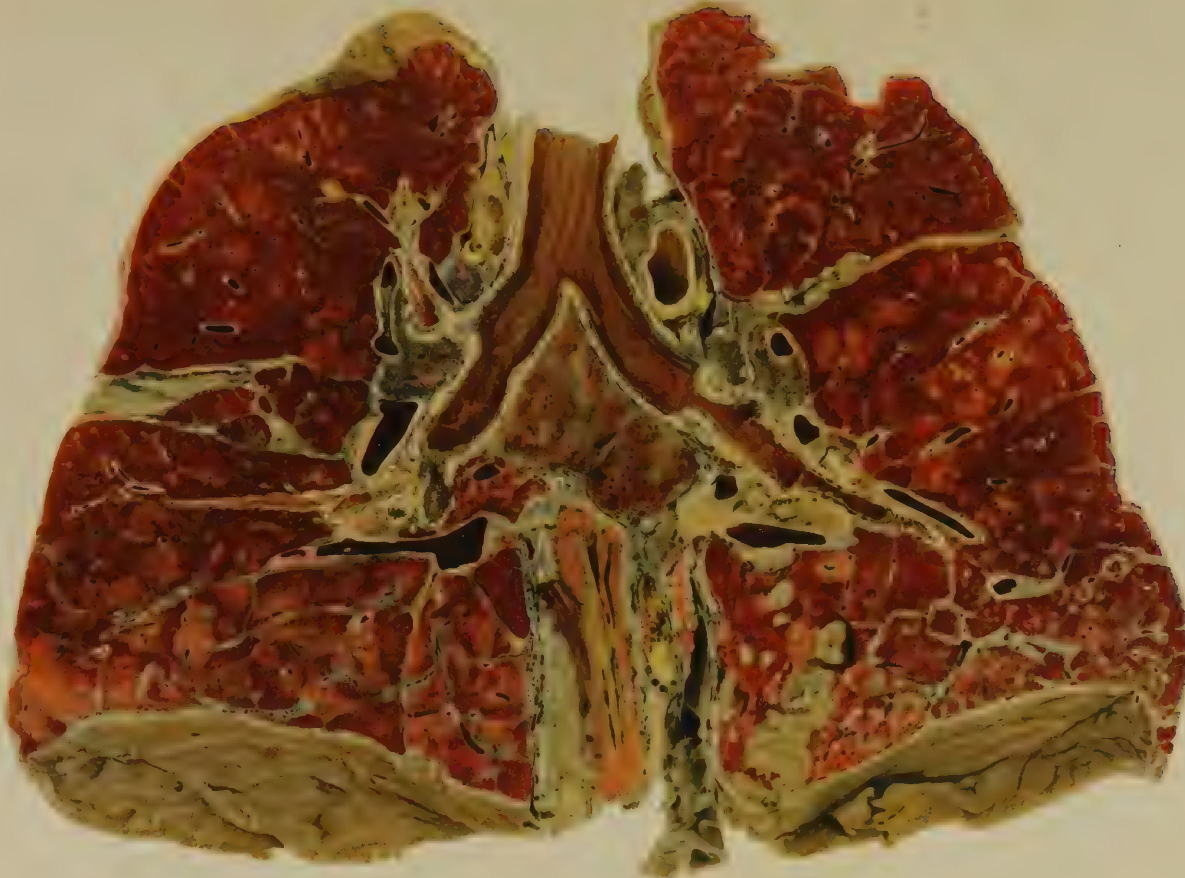
Other antiseptics noted in the special empyema records,[1] with the number of cases in which they were employed, are listed below:

	Cases.
Formalin	162
Dichloramine–T	73
Bismuth	65
Boric acid	14
Chlorazene or chloramine–T	11
Cresol	10
Iodine	7
Mercuric chloride	5
Optochin	3
"B. I. P." (bismuth subnitrate, 1 part; iodoform, 2 parts; liquid paraffin oil, sufficient to make a thick paste)	2
Potassium permanganate	2
Aniline dyes	2
Hychlorite	1
Iodoform	1
Silver nitrate	1
Urotropin	1
Quinine	1

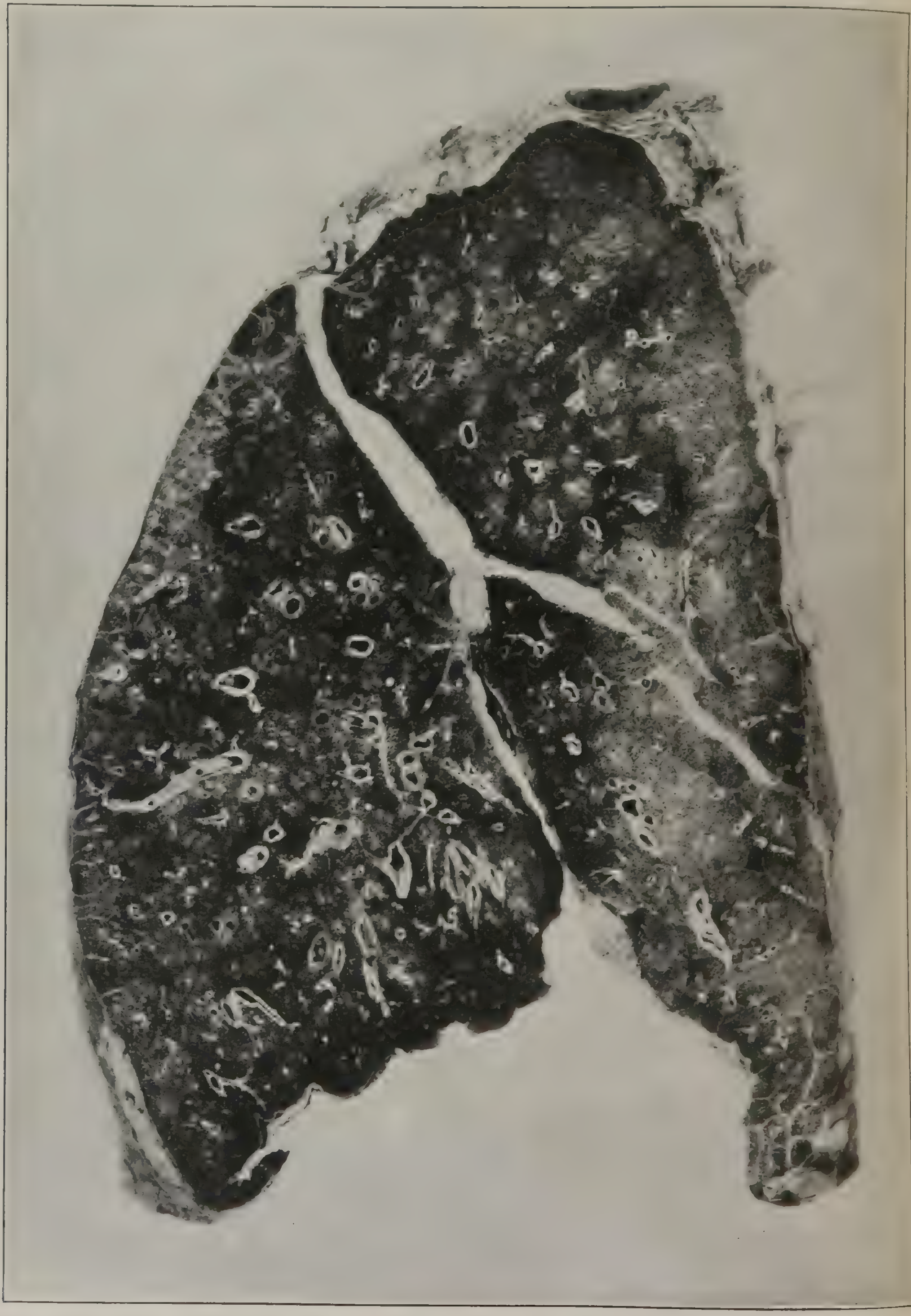
In 40 cases a 50 per cent solution of glucose was instilled into the cavity, and in 4 additional cases glucose was combined with formalin.

In none of the cases included in this list are there records of bacteriologic studies of the progress of disinfection which throw light upon the value of the

PLATE V.



INTERSTITIAL BRONCHOPNEUMONIA WITH BILATERAL EMPYEMA AND FIBRINOUS PERICARDITIS DUE TO HEMOLYTIC STREPTOCOCCI. ACCESSION NUMBER 3,300. ARMY MEDICAL MUSEUM.



AN ENCAPSULATED INTERLOBAR EMPYEMA DUE TO HEMOLYTIC STREPTOCOCCI. ARMY MEDICAL MUSEUM ACCESSION NO. 3106.

PNEUMONIA DUE TO AN INFECTION WITH HEMOLYTIC STREPTOCOCCI FOLLOWING INFLUENZA. ACCESSION NUMBER 3,133. ARMY MEDICAL MUSEUM.

antiseptics used. It is obvious, however, that the results did not encourage the extensive use of any antiseptics other than those belonging to the chlorine group.

A number of cases at Camp Pike and Camp Dodge were treated by the "closed method." An open thoracotomy was not done. The cavities in these cases were aspirated and irrigated with Dakin's solution and formalin through a catheter inserted through a puncture wound in the chest wall. For an evaluation of these two antiseptics and of the various methods employed in the treatment of empyema, a preliminary review of the difficulties met in the disinfection of the pleural cavity is necessary.

CONDITIONS INFLUENCING STERILIZATION.

The first essential for successful disinfection is contact between the antiseptic and the organisms it is designed to destroy. A glance at the illustrations in the chapter on the pathology of empyema will reveal many of the conditions which render this difficult. It is at once apparent that the bacteria may be enmeshed in a fibrinopurulent exudate between two adjacent lobes of a lung, or that exudate may bind the lung to the costal wall or to some other portion of the parietal layer of the pleura. In addition there may be subpleural pulmonary abscesses which communicate with the pleural cavity through small fistulas. Furthermore, firm adhesions may divide the pleural space into pockets which are either completely isolated or which communicate with each other by narrow and possibly tortuous channels.

The clinical course, X-ray and bacteriologic examinations during life, as well as the post-mortem findings in fatal cases, show that empyemata differ to an extraordinary degree in the character and extent of the infection. There are cavities of simple conformation, confined to a relatively small part of the pleura, and infected by bacteria which succumb to protective reactions developed in the host. In the absence of untoward circumstances such cases are self-limited. Simple drainage and protection from secondary infection usually meet the indications for treatment. Post-mortem examination of the more complex cases shows that they are usually, if not always, associated with acute interstitial pneumonia, which was prevalent in certain camps. They are usually due to infection with hemolytic streptococci. The suppurative process is not confined to the pleura, but extends to the interlobular areolar tissue, and causes minute abscesses immediately beneath the pleural surface or deep within the lung parenchyma. The intrathoracic conditions in these complex cases are of such importance in the problem of disinfection that they must be studied in some detail. Cases of this character usually die early in the course of the disease with associated infections of other viscera. A small percentage of them live and tend to become chronic.

The interlobar agglutinations occurring in these cases are well illustrated in Plates V, VI, and VII. In Plate V a small abscess opens into the interlobar cleft. The interlobular connective tissue within the lung is so swollen by the exudate within its meshes that it forms broad lines which separate the lobules; in the normal lung these boundaries are inconspicuous.

The interlobar clefts are not, however, the only sites in which such adhesions occur. They may be found in any situation where the pleural surfaces were

in contact at the time infection occurred and were not separated immediately by an accumulation of fluid. A very instructive series of frozen sections (Figures 15 to 22) through the thorax of a cadaver in which there was a serofibrinous effusion into the right pleural cavity, shows the situations in which such a disruption of the fibrinous adhesions failed to take place when the cavity was filled with exudate.[a] After the body was frozen in the supine position, parallel transverse sections about 1 inch in thickness were made through the thorax and abdomen. Only those which include the pleurae are of importance here. There is no clinical record of this case, but it is evident that any pneumonia which may have preceded the pleuritis had undergone substantial resolution before death, since there is no evidence of pulmonary consolidation in the sections from which these photographs were taken. The areas in which the opposed pleural surfaces remain in contact, in spite of a massive effusion, include nearly the whole of the cavity anterior to the root of the lung. The lung appears to be in contact with the upper surface of the diaphragm as well. It is interesting that the diaphragm is normally higher on the right. It is not unlikely that this difference in levels is increased in this case by a relaxation of the muscles following the pleuritis on the affected side. A natural consequence of such a relaxation would be to deepen and narrow the sulcus between the diaphragm and thoracic wall below the inferior margin of the lung. This sulcus can be traced through at least four of these frozen sections below the level where they include portions of the lung. Had the fibrinous exudate been as abundant in this case as it was in many of the cases of empyema occurring in the Army, this sulcus would have been completely filled with a fibrinopurulent deposit which would have bound the two pleural surfaces together. It is in these regions where a deposit of fibrin holds the serous surfaces together that permanent fibrous adhesions are subsequently formed.

The conditions described above have a bearing on the results of attempts at disinfection by antiseptic solutions introduced into the portions of the pleural cavity made accessible by thoracotomy. Thin layers of infected fibrin lying between the lobes of a lung or between the visceral and parietal pleuræ prevent thorough contact of the antiseptic with organisms enmeshed throughout the whole extent of the fibrinous deposit. The contents of pus pockets within this fibrin or in subpleural or intrapleural abscesses are also well protected against antisepsis. An antiseptic must have either great power of penetration, or solvent properties adequate to remove the obstructing fibrin or dead tissue if it reach bacteria present under these conditions.

This brief exposition indicates some of the factors preventing thorough disinfection of empyema cavities. There is, however, one other condition that frequently prevents the introduction of fluid antiseptics in quantities sufficient to be of much value. If a peripheral abscess of the lung ruptures into the pleural space, a communication is often established which allows the flow of fluids from the pleural cavity into the bronchial tract. Such pleurobronchial communications were frequent in cases of empyema following streptococcus bronchopneumonia. Sometimes their presence was revealed only when irrigation of the cavity was first attempted. The introduction of the solution into

[a] These sections were made and photographed by Prof. Thomas Dwight and were available for use in this study through the courtesy of the anatomical department of the Harvard Medical School.

POSTERIOR SURFACE OF THE LUNG ILLUSTRATED IN PLATE VII.
ARMY MEDICAL MUSEUM ACCESSION NO. 3133.

45267°—24——12

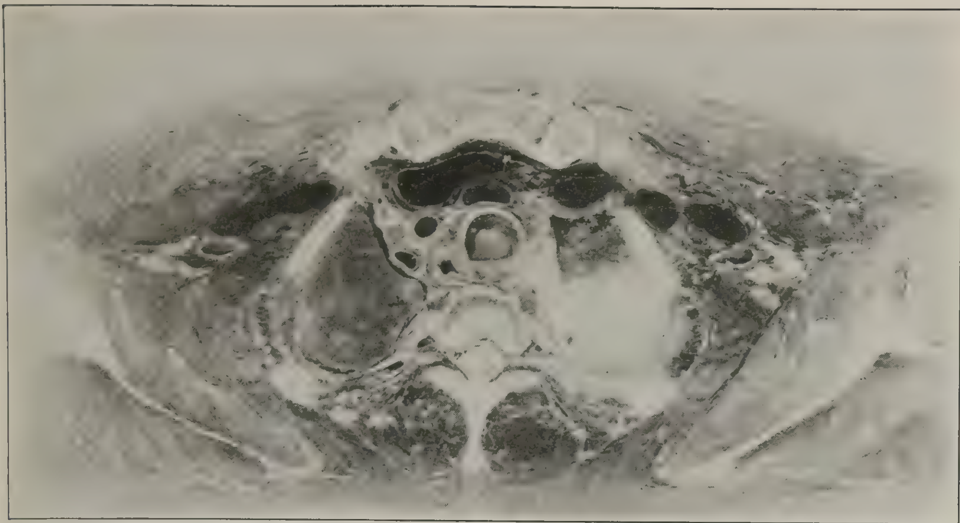


FIG. 15.—This and the following illustrations, to Fig. 22, represent a series of frozen sections through the thorax to demonstrate the position of a lung compressed by a large effusion.

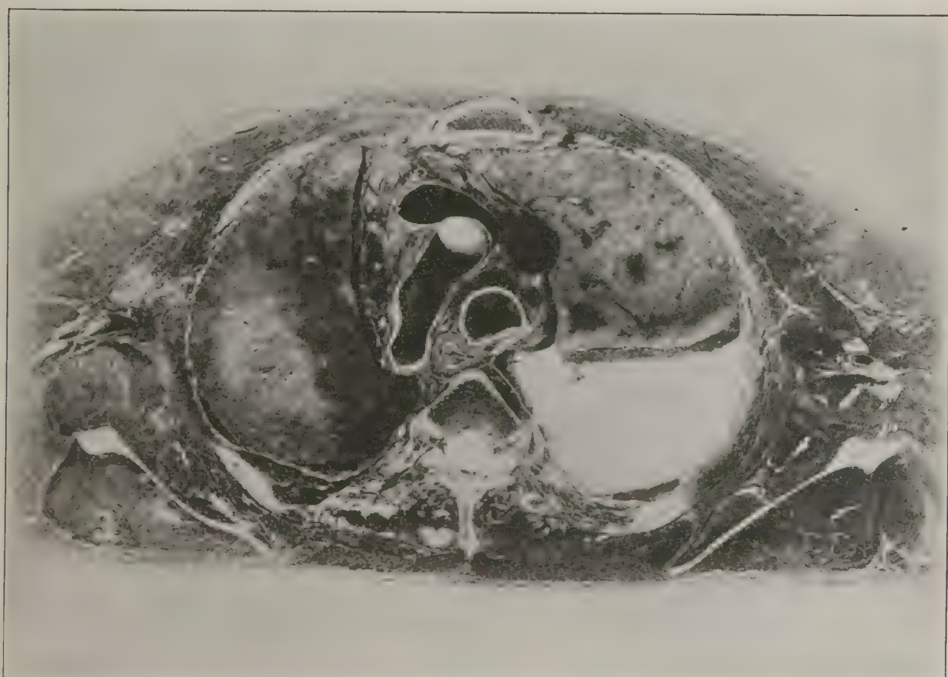


FIG. 16.

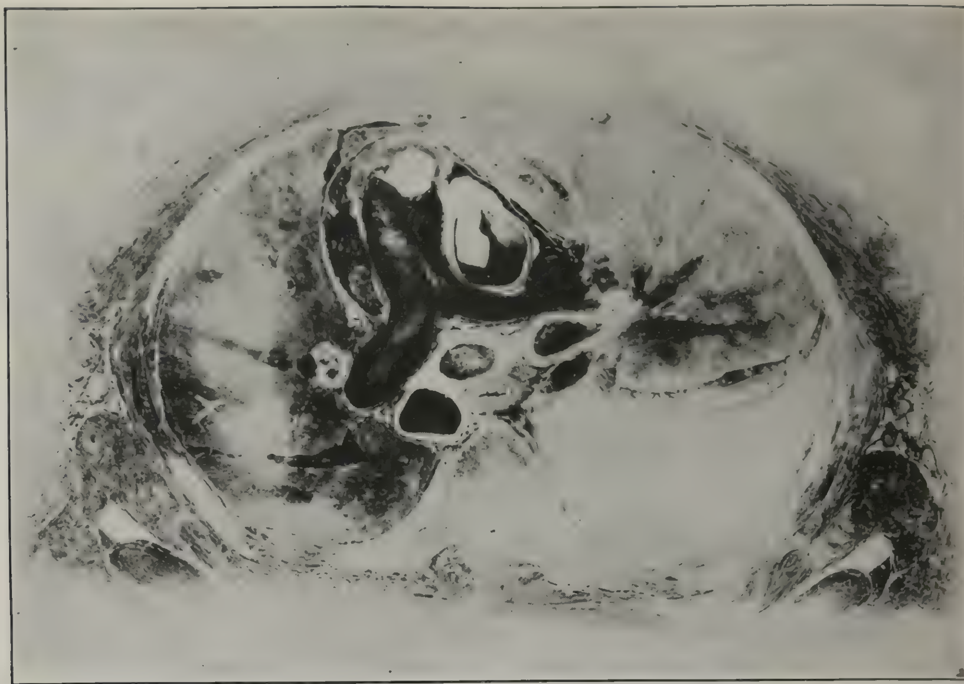


Fig. 17.

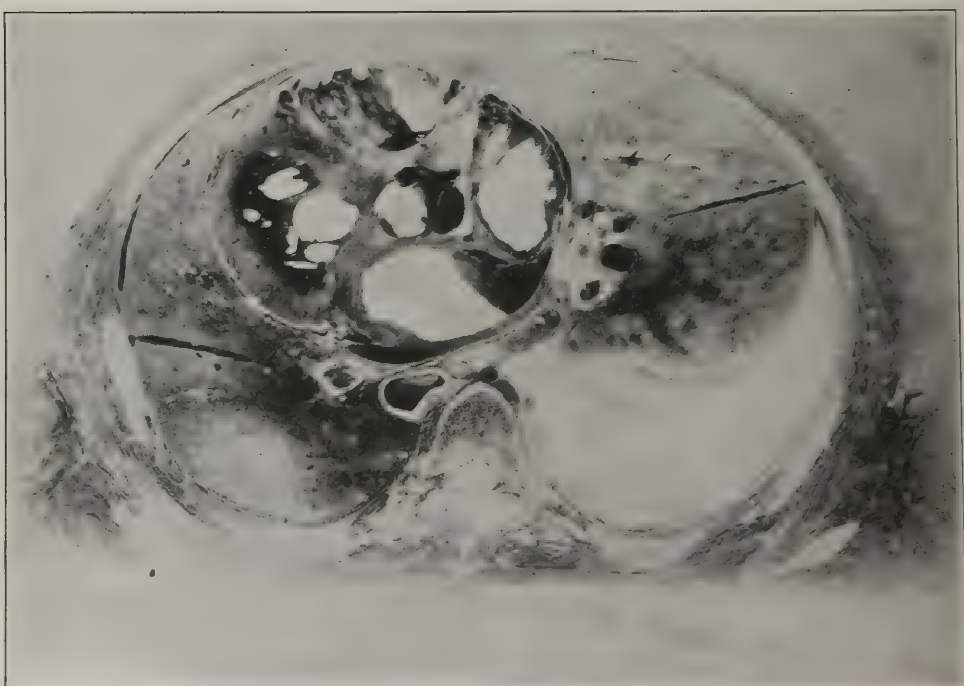


Fig. 18.

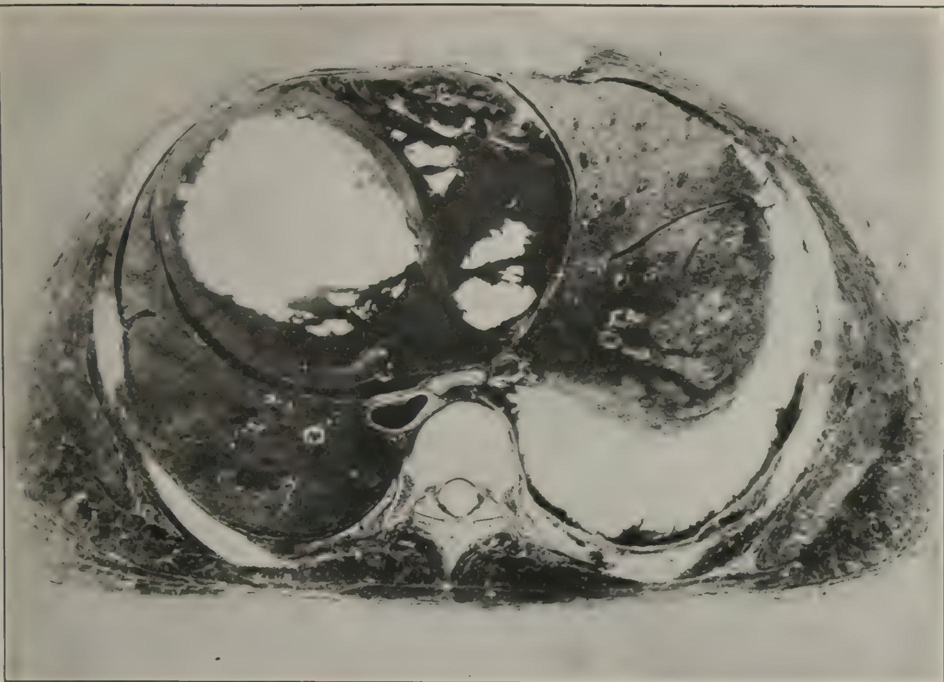


FIG. 19.

FIG. 20.

FIG. 21.

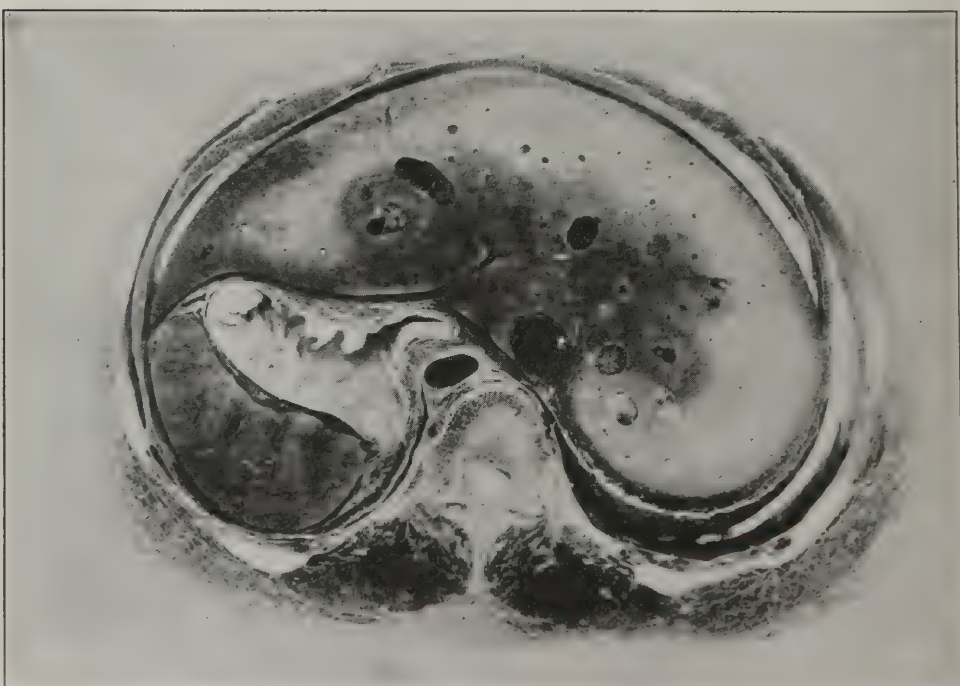


FIG. 22.

the cavity in these cases induced coughing. The patients could then taste the solution which had been used. In other cases there was no evidence of a pleuro-pulmonary fistula until frequent irrigations or instillations had been practiced for an extended period of time. In these instances the pleural opening was probably covered by fibrin which was later dissolved by the sodium hypochlorite, or the abscess had not ruptured when irrigation was first attempted. When these pleurobronchial communications were large and patent they prevented irrigation. In many cases the instillation of small amounts of solution was possible if the patients were placed in a position which did not allow fluid to enter the bronchi.

Hitherto only those impediments which are of a mechanical nature have been touched upon. There are, however, difficulties in which chemical factors play a great part. These, of course, must be overcome if successful disinfection of the entire cavity and its various ramifications is to be secured. Germicidal substances must be considered, not solely with reference to the bacteria which they are designed to destroy, but their reactions with the exudate and tissues must be understood. Many antiseptics act by coagulating proteins, and, if they are in sufficient concentration, kill animal as well as bacterial cells through a fixation of the cytoplasm. Other antiseptics, particularly those containing active chlorine, react with proteins by altering their chemical constitution. The products of the reactions induced by Dakin's solution are soluble on account of the active chlorine. In whatever class an antiseptic may belong, the reactions in which it takes part must reduce its potency as a germicide, since they reduce the concentration of available antiseptic. Substances in solution enter into these reactions more readily and promptly than those in particulate form, so that the antiseptic available for germicidal action may be greatly reduced in exudates containing large amounts of fibrin or soluble protein. The influence of these side reactions in reducing the efficiency of antiseptic applications must, therefore, be kept in mind in this form of treatment.

The surgical treatment of empyema differs from that of wounds of the soft parts in that the septic area can not be opened freely so that perfect drainage and irrigation can be obtained. It is not a simple matter to select a site for thoracotomy that will with certainty drain the most dependent part of the cavity. There is great danger in attempting to drain the cavity through the sulcus between the diaphragm and costal wall, for instances are on record in which the diaphragm was perforated at operation, with subsequent infection of the peritoneum. In some of these cases the site of operation was as high as the seventh intercostal space in the midaxillary line. It is doubtful if thorough drainage of this sulcus is secured by thoracotomy at the level at which the incision is usually made.

The difficulty experienced in completely draining the cavity has been mentioned because it is a factor which greatly influences the success of attempted disinfection. Residual quantities of exudate always reduce the germicidal potency of antiseptics, but especially of antiseptics of high reactivity, such as those of the chlorine group. These highly reactive antiseptics, however, are precisely the ones which offer the greatest promise of success, because they are strongly bactericidal in concentrations which will not destroy living tissues.

Even when drainage is perfect, the secretions are often formed so rapidly and in such large quantities that the concentration of the antiseptic solution is reduced by simple dilution. For this reason antiseptics which act almost instantaneously are the most potent.

In view of all the adverse factors enumerated, the sterilization of an empyema cavity might well appear a hopeless task. In many instances this has proved the case. It is possible, however, to sterilize a very high percentage of cases after persistent effort if certain facts are constantly kept in mind. Based on this review of the difficulties encountered, the following definite conclusions may be drawn. All foci of infection must be made accessible to the disinfectant; the secretions formed within the cavity must be evacuated as completely as possible; and an antiseptic of rapid action must be chosen when the secretions are abundant. It appears, then, that the choice of an appropriate antiseptic and a proper mode of application are of prime importance. The neutral solution of sodium hypochlorite, which has been so extensively used in the treatment of septic wounds, has met these conditions more perfectly than any other antiseptic and, in consequence, has been most frequently used in the postoperative treatment of empyema.

There are two methods of using the data available in determining the value of Dakin's solution in the treatment of empyema. One of these is the bacteriologic study of the progress of disinfection in individual cases. The other is a comparison of the results of that treatment with those following other procedures. In either of these methods difficulties of interpretation are encountered because of variations in the bacteriology and pathology of the cases. Post-mortem examinations of fatal cases, and the clinical histories of those surviving, reveal such great variations in the course of the infection that it is impossible to select groups of cases which present common salient features for study. In some individual cases it is evident that undiscovered foci of infection have prevented successful sterilization of cavities for periods of months.

Since cases can not be compared individually in respect to the intrathoracic conditions, it is necessary to consider them in large groups in order to eliminate possible individual differences. The study then becomes purely statistical and definite criteria must be selected for comparison of the groups. Two quite different criteria have been selected for this comparison. The first is the length of time which elapsed between the first open operation and the closure of the thoracic wound. The second is based upon replies to follow-up letters,[2] and refers to the ability to work, the presence of dyspnea, pain, persistent cough, and cardiac symptoms. These criteria are both objective and subjective. The closure of the wound is an objective event noted by a surgeon in charge of the case. The replies received from the men after discharge from the Army are largely subjective.[2] The evidence bearing upon the efficiency of antiseptic treatment with Dakin's solution is, therefore, varied in character.

The study of these data has required a consideration of all the available material en masse and further study of a few individual groups of cases which were under more careful observation by a commission established by the Surgeon General of the Army.[3] This has been necessary on account of the character of the treatment which was altered from time to time throughout all the Army camps as the methods of sterilization were improved. Without the data

on these more intensely studied cases a general survey of the entire situation would be grossly misleading. For this reason the statistical study has been subdivided under headings which are intended to present the effects of treatment on all the cases for which suitable records are available and to clarify more points raised by this general survey. Various other descriptive data have been appended as a matter of record.

THE EFFECT OF ANTISEPSIS WITH NEUTRAL SOLUTION OF SODIUM HYPOCHLORITE ON THE HEALING OF THORACOTOMY WOUNDS.

From the entire group of cases which were treated by open drainage, 1,113 have been selected as a basis for study. Obviously, the most important fact which could be gleaned from such a group of cases would be the effect of irrigation on the length of the drainage period. No discrimination was employed in the selection, but all cases in which the data were accurate in regard to the date of operation, the application of Dakin's solution, and the final closure of the wound were used for study. With these three definite points in mind these cases were divided into smaller groups for comparison. These smaller groups have been termed "simple drainage," "Dakin-part,"and "Dakin-full."

In the first group the clinical history mentions no antiseptic treatment, and the postoperative care is designated as "simple dressings," or "drainage." This group of cases, numbering 510, is designated by the term "simple drainage." In the other two groups Dakin's solution was used at some stage in the course of the postoperative treatment. The technique followed in the application of this solution was not uniformly the same, nor were irrigations always continued throughout the course of the postoperative care up to the time of wound closure. In some instances the only reference to Dakin's solution is the statement that it was used for daily irrigation at the time dressings were renewed. Since the antiseptic action of the hypochlorite is transitory, a single application at daily intervals can not be regarded as an efficient utilization of this solution for attaining sterilization of the pleural cavity. These cases have therefore been collected to form a second and a third group, "Dakin-full," in which the records specify that Dakin's solution was instilled at intervals of from one to three hours during the day and at less frequent intervals during the night, and "Dakin-part," in which treatment was not so persistent. These two groups aggregate 603 cases, of which 455 fall into the "Dakin-part" series and 148 into the "Dakin-full."

The first step in the analysis of each of these individual groups of cases has been a rearrangement of each series based on the interval of time which elapsed between the operation and the perfect closure of the wound. Such an arrangement permits the construction of a curve for each group. When the curves for all of these groups are charted to illustrate the percentages of cases healed at different intervals of time after the first open operation the results of the three methods of treatment can be compared in graphic form. The manner in which this chart was constructed necessitates an explanation.

There were 510 cases treated by simple drainage. The intervals between operation and wound closure in these cases ranged from 13 to 389 days. If the total number of days, made up of the sum of the intervals in all these cases, is divided by the number of cases studied the mean interval for the whole

series would be 84.547 days. In other words, this was the average healing time. The majority of the cases, however, healed before this number of days had elapsed. As a matter of fact 297 healed within this period and 213 healed later. The mean closure time for the 297 cases was 55.714 days. Again, 140 cases healed in less than this interval and 157 healed between 55.714 days and 84.547 days, which is the mean period for the entire group. Taking in turn the mean time of healing for the 140 earlier cases it is found to be 39.014 days, with 65 of the cases healing prior to that interval and 75 cases between this and the secondary mean of 55.714 days. In like manner, these 65 cases fall into two groups of 30 to 35, respectively. The mean of the 30 cases is 22 days, and that of the 35 cases 33.97 days.

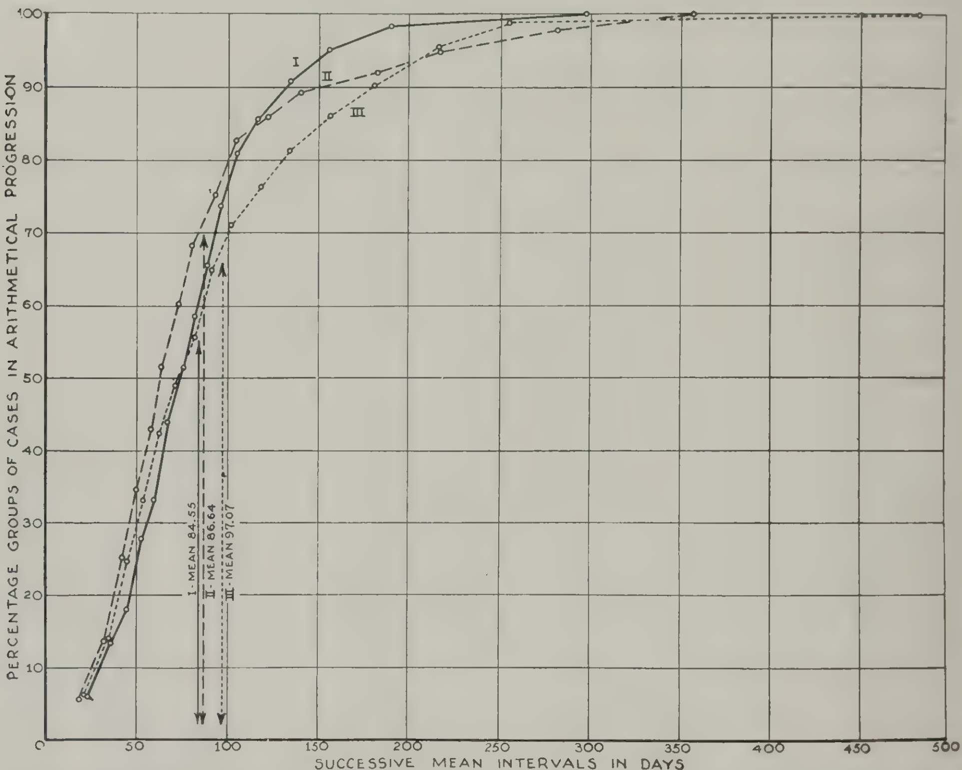


CHART LVIII.—Intervals between first operation and closure of the thoracic wound. Curve I, simple drainage (see Table 36). Curve II, Carrel-Dakin, full technique (see Table 38). Curve III, Carrel-Dakin, part technique (see Table 37).

In this way, by determining the successive means of the first, second, third, and fourth orders, the whole series was divided into 16 groups. The number of cases falling within each group was determined and the percentage ratio which this number bore to the total number in the series was obtained. When these percentages were successively added together they gave the percentage of cases which had healed at successive intervals after operation. These intervals were the mean closure periods for each of the 16 groups. The sums of the percentages were plotted as ordinates over abscissæ which represent the sums of corresponding mean times of closure. The calculations on each of the three large groups of cases have been appended in Tables 36, 37, and 38. Chart LVIII is a combination of the three curves constructed from these tables.

TABLE 36.[a]—*Wound closure after first operation—Distribution of cases among successive mean periods—Postoperative treatment, simple drainage.*

Distribution.										
Cases.						Mean periods in days.				
Total number.	Successive groups.				Per cent of total in fourth group.	Successive groups.				Average mean period.
	First.	Second.	Third.	Fourth.		Fourth.	Third.	Second.	First.	
510	297	140	65	30	5.882	22.00	28.45	39.01	55.71	84.55
				35	6.863	33.97				
			75	30	5.882	43.60	47.13			
				45	8.824	51.58				
		157	84	27	5.294	58.70	61.24	70.50		
				57	11.176	65.95				
			73	36	7.059	75.06	78.43			
				37	7.255	81.70				
	213	140	79	37	7.255	88.51	92.48	100.3	124.8	
				42	8.235	95.98				
			61	35	6.863	105.5	110.5			
				26	5.098	117.1				
		73	48	25	4.902	134.1	144.3	171.6		
				23	4.510	155.4				
			25	17	3.333	189.6	224.0			
				8	1.569	297.1				

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

TABLE 37.[a]—*Wound closure after first operation—Distribution of cases among successive mean periods—Postoperative treatment, Dakin-part.*

Distribution.										
Cases.						Mean periods in days.				
Total number.	Successive groups.				Per cent of total in fourth group.	Successive groups.				Average mean period.
	First.	Second.	Third.	Fourth.		Fourth.	Third.	Second.	First.	
455	295	150	62	28	6.154	20.32	27.87	38.77	58.08	97.07
				34	7.473	34.09				
			88	49	10.770	44.50	48.27			
				39	8.571	53.44				
		145	70	42	9.231	62.40	66.06	76.81		
				28	6.154	71.54				
			75	33	7.253	81.12	86.85			
				42	9.321	91.35				
	160	96	51	27	5.934	102.6	110.0	126.4	168.9	
				24	5.275	118.3				
			45	23	5.055	133.5	145.0			
				22	4.835	156.8				
		64	43	19	4.176	180.8	200.5	232.8		
				24	5.275	216.0				
			21	17	3.736	255.3	298.9			
				4	0.879	483.5				

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

TABLE 38.[a]—*Wound closure after first operation—Distribution of cases among successive mean periods—Postoperative treatment, Carrel-Dakin technique.*

Distribution.										
Cases.						Mean periods in days.				
Total number.	Successive groups.				Per cent of total in fourth group.	Successive groups.				Average mean period.
	First.	Second.	Third.	Fourth.		Fourth.	Third.	Second.	First.	
148	101	51	20	8	5.405	18.63	26.90	38.31	53.46	86.64
				12	8.108	32.42				
			31	16	10.811	41.69	45.68			
				15	10.135	49.93				
		50	25	12	8.108	57.41	60.67	68.90		
				13	8.784	63.85				
			25	13	8.784	73.39	77.04			
				12	8.108	81.00				
	47	31	21	10	6.757	94.00	99.95	110.1	157.9	
				11	7.432	105.4				
			10	5	3.378	122.5	131.3			
				5	3.378	140.0				
		16	9	4	2.703	182.5	207.5	250.7		
				5	3.378	217.0				
			7	4	2.703	281.5	313.7			
				3	2.027	356.7				

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

There are many circumstances to be taken into consideration in attempting to interpret the relations between the curves, which could not be illustrated in this chart. Chief among these is the fact that the cases were not uniformly distributed throughout the epidemiologic periods. Since Dakin's solution was not used in the treatment of empyema, except in a few isolated instances, until March or April, 1918, the curve for simple drainage is made mostly from cases which occurred early in the epidemic. Before this time few antiseptic measures were employed because it was deemed hazardous to irrigate empyema cavities with even bland solutions. This lack of synchronism in the curves introduces an element of uncertainty as to whether the cases included under simple drainage were of the same character as those upon which the other curves are based. The curves resulting from this method of analysis are sufficiently well defined, however, to permit a comparison of the three groups of cases. These curves show the same general character, with a fairly steep and nearly uniform gradient that comprises about 70 per cent of all cases. The remaining 30 per cent show a gradually increasing tendency toward chronicity, which is least marked in the cases treated by simple drainage.

Based entirely upon the relations of these curves, the conclusion might be reached that cases treated by simple drainage progressed more favorably than those in which Dakin's solution was used, but that full Carrel-Dakin technique was more effective than less intensive treatment of the cases. Such a conclu-

sion would be paradoxical, of course, and would indicate that some factor not hitherto considered enters into the distribution of the cases grouped according to the various modes of treatment. The obvious conclusion would be that those which were treated by simple drainage were in general less refractory than those receiving antiseptic treatment. There is no basis, however, for such a conclusion, since the mortality from empyema and the pathology of the cases indicate that the disease was probably more severe when simple drainage was the common mode of treatment than later when antisepsis was in vogue.

Neither of these conclusions would be wholly correct. Many of the most refractory cases occurred in the latter part of 1917 and the first two or three months of 1918, when the morbidity was high. The mortality in this period of high incidence was at its maximum, and many of the cases that survived ran a very protracted course before healing. Few of these protracted cases, however, were treated throughout their course by simple drainage. If they failed to heal under that treatment within a period of three or four months after the first operation they were either transferred to hospitals where Dakin's solution was employed, or the Carrel-Dakin technique was introduced into the wards of the hospital where they were being treated. In the construction of these curves it was not feasible to separate the cases into groups on the basis of these transfers or changes of treatment. All the cases which were treated with Dakin's solution, irrespective of the antecedent history, were included in one or the other of the curves. This grouping was necessitated by the general lack of specific information concerning the date on which chlorine antiseptics were first used. This information is available only in a limited group of cases, which will be referred to presently.

From the above considerations it would appear that the curve for simple drainage is unduly favorable to this mode of treatment when compared with the use of Dakin's solution. Without more precise data concerning the individual cases, it would be unprofitable to attempt a closer analysis of these three groups.

While these curves can not be considered as strictly accurate, they furnish a means for comparing the three methods of postoperative treatment which can be accepted as reasonably satisfactory. This is particularly true of the two curves representing cases treated with Dakin's solution, for with certain exceptions these fall within the same epidemiological period of time, and the character of the majority of the cases was presumably similar in the two groups.

It may be pointed out that in 50 per cent of the cases treated with the full Carrel-Dakin technique the wounds closed in approximately 63 days, while 50 per cent of those treated less efficiently required about 74 days for healing. This is a saving of 11 days, or nearly 15 per cent of the time required for the more chronic cases. In like manner, it is observed that 70 per cent of the Dakin-full cases healed in 85 days, in contrast to 101 days for the Dakin-part cases. This is a difference of 16 days, nearly 16 per cent of the time required by the cases in the latter group.

The foregoing figures refer only to the time which elapsed between the first operation and the closure of the wounds. It is pertinent to inquire into the percentage of these cases in which the closure was permanent. While it was possible to limit the cases to those included in the three groups just studied,

it was advisable to enlarge these groups by the addition of certain cases in which definite data were lacking concerning the date of wound closure. Many of the recurrences at the site of operation were at long intervals after the onset of the empyema and necessitated follow-up letters over an extended period. They have been reported at an interval as long as 1,100 days after the onset of the infection.

Among 1,043 cases in which simple drainage was the only postoperative treatment, follow-up letters were returned by 713, or 68.35 per cent.[2] Recurrences of the empyema were reported in 82 (7.86 per cent) of the total 1,043; 11 occurred after return to quarters before discharge from the Army, and 71 after discharge. Of these 82 recurrent cases, 5 died subsequently. One of the deaths followed pulmonary tuberculosis, and the four others were associated with tuberculosis in advanced stages. Twenty-two were receiving compensation for temporary partial disability, 1 for permanent partial disability (15 per cent), 11 for temporary total, and 1 for permanent total (tuberculosis). Nine of the 82 cases were receiving vocational training; 10 were incapacitated for any work; 23 were doing light work; 6 stated that they were able to work though hampered by dyspnea, pain or symptoms referred to the heart. It is evident that these men were in poor condition and that in the majority of cases the recurrence was not a trivial matter.

There were 489 follow-up replies [2] from the 723 cases in which the postoperative treatment was irrigation with Dakin's solution (partial technique); that is, 67.50 per cent responded to inquiries as compared with 68.36 per cent of those treated by simple drainage. There were 44 recurrences among the 723 cases, or 6.08 per cent. Twenty-five occurred after discharge from the Army; 13 after return to quarters, but before discharge; and the remaining 6 were still in the service, but no note was made of the date when these men left the hospital; 1 case died of unknown cause after discharge from the Army; 5 of the recurrent cases were tuberculous. Thirteen of the 44 cases received compensation for temporary partial disability, 2 for permanent partial, 8 for temporary total (1 tuberculous), and 3 for permanent total (1 noted as tuberculous). Nine cases received vocational training. Five of the men reported that they were unable to work, 8 were doing light work, and 10 full work.

Of the 252 cases in which the complete Carrel-Dakin technique was used after operation, 167 replied to inquiries [2] concerning their condition. This is 66.27 per cent, a somewhat smaller proportion than in the other two groups. There were 13 recurrences, 5.16 per cent. Of these, 9 occurred after discharge from the Army, 1 after return to quarters before discharge, and 3 were still in the service, though the time when they left the hospital is not recorded. Those receiving compensation for disabilities were rated as follows: Temporary partial, 5; temporary total, 4; 5 received vocational training. None was reported as tuberculous, though there is some doubt as to whether all the cases rated for temporary total disability were not tuberculous.

These data are too incomplete for tabulation. They give only a general idea of the conditions presented by cases that suffered a relapse. There is no clear indication that the infecting organism originally found in the pleural exudate, or the nature of the disease preceding empyema, had any influence in determining a recurrence. There are no data concerning the organisms present n the fluid after relapse.

THE BACTERIOLOGICAL STUDY OF THE PROGRESS OF DISINFECTION AT CAMP LEE.

Before it is possible to analyze the smaller group of cases mentioned in the preceding section, the methods of study must be considered in detail. The most complete data relative to the action of solutions of sodium hypochlorite in the sterilization of empyema wounds are from Camp Lee. Here many of the cases were treated throughout by irrigation, and others, which had not healed under simple drainage within three or four months, were transferred to Carrel-Dakin technique. The purpose of the bacteriological study was to determine the number of viable bacteria in the same amount of pleural exudate at intervals during the period of antiseptic treatment. The method which was employed has been described by Garbat, who continued this study on the cases of empyema that were transferred from Camp Lee to General Hospital No. 12 on June 31, 1918.[4]

Samples of exudate were obtained at frequent intervals when cases were dressed. These samples were collected by filling standard-sized platinum loops which were capable of holding approximately 0.02 gram. Each sample of exudate was immediately mixed with about 1 c. c. of a sterile 1 per cent solution of sodium thiosulphate, which neutralized any chlorine antiseptic which might remain in the sample from the previous irrigation. These procedures were carried out at the bedside immediately after the dressings and the tubes inserted in the cavity had been removed, but before the cavity was irrigated.

The samples were then taken to the laboratory and thoroughly mixed in a Petri dish with defibrinated blood and melted agar. After the agar had solidified, the plates were incubated for 24 hours at 37° C.

As far as possible, the walls of the sinus were avoided and the secretion was taken from the cavity. This precaution was necessary, particularly in cases which had been under treatment for a considerable length of time. In these cases the tissues of the thoracic wall fitted closely around the tubes so that the secretions between the tubes and walls of this sinus were protected from the antiseptic except at the time the cavities were irrigated, with the drainage tubes removed. These secretions usually contained bacteria which had invaded the sinus in spite of rigid antisepsis during the dressing of the wounds. These bacteria had been free to multiply until swept away or destroyed at the next irrigation. Samples of this material could not give a true picture of the bacteriologic flora of the main part of the draining tract.

When disinfection had proceeded to a point where sterility was nearly or fully attained, the secretions within the cavity were often so scanty that the wire loop used for securing the sample could not be completely filled. Under these circumstances the number of bacteria could only be approximated, but a sufficient quantity of secretion could always be obtained to verify or disprove sterility.

In all the cases studied in this way at Camp Lee, the primary infections were due to hemolytic streptococci.[5] The use of blood-agar as a culture medium made it possible, therefore, not merely to enumerate the total number of colonies upon the plate, but also to distinguish and estimate the number of these bacteria present. The counting was done either with the unaided eye or a hand glass, or under the low power lens of the microscope; a series of frac-

tional areas of the plate were averaged and multiplied by the proper factor, thus giving the approximate number for the entire plate.

In some of the cases studied in this way the application of Dakin's solution was carried out immediately after thoracotomy. In other instances a considerable period of simple drainage had intervened between the operation and the institution of this treatment. The data concerning these changes in treatment, the time when hemolytic streptococci were eliminated from the pleural exudate, and the time of wound closure or healing are given later in Tables 45, 46, and 47, and in Chart LXII.

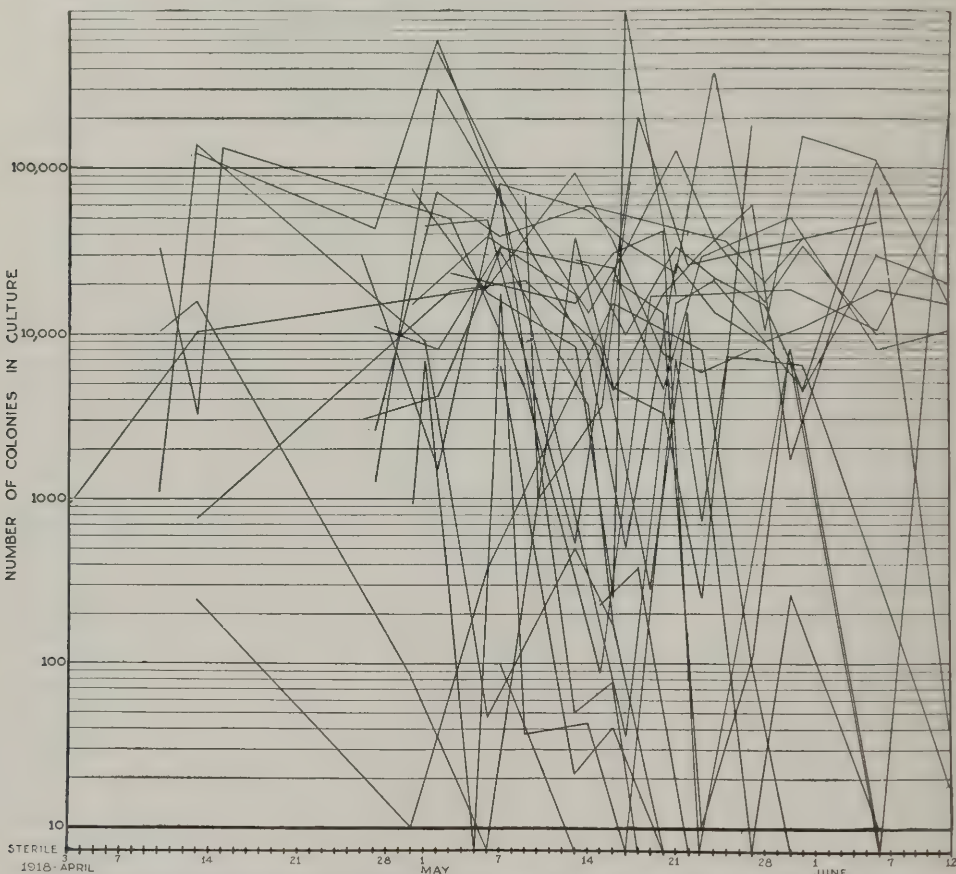


CHART LIX.—Graphic illustration of the total number of colonies on plates made at intervals during the disinfection of cavities, Camp Lee, Va.

These data must be supplemented by following the fluctuations in the number of viable organisms present in the exudate from time to time during the period of antiseptic treatment. These fluctuations in 24 cases picked at random are shown in Chart LIX. The dates on which the exudate was sampled are used as the abscissæ, and the number of colonies on the plated cultures taken for the ordinates. These are plotted on a logarithmic scale, with an arbitrary line at the bottom indicating a sterile culture. The definite ordinates range between 10 colonies on the plate to 900,000. By using this logarithmic scale great differences in the number of colonies can be included on a chart of reasonable proportions.

At first glance, the lines upon this chart appear to form a tangled skein lying between 1,000 and 100,000. Some of the lines never leave this zone of a fairly constant infection, but occasionally a line descends sharply, indicating a rapid decrease in the number of organisms in the exudate. In a few instances this descending line reaches the level which indicates sterility. In some in-

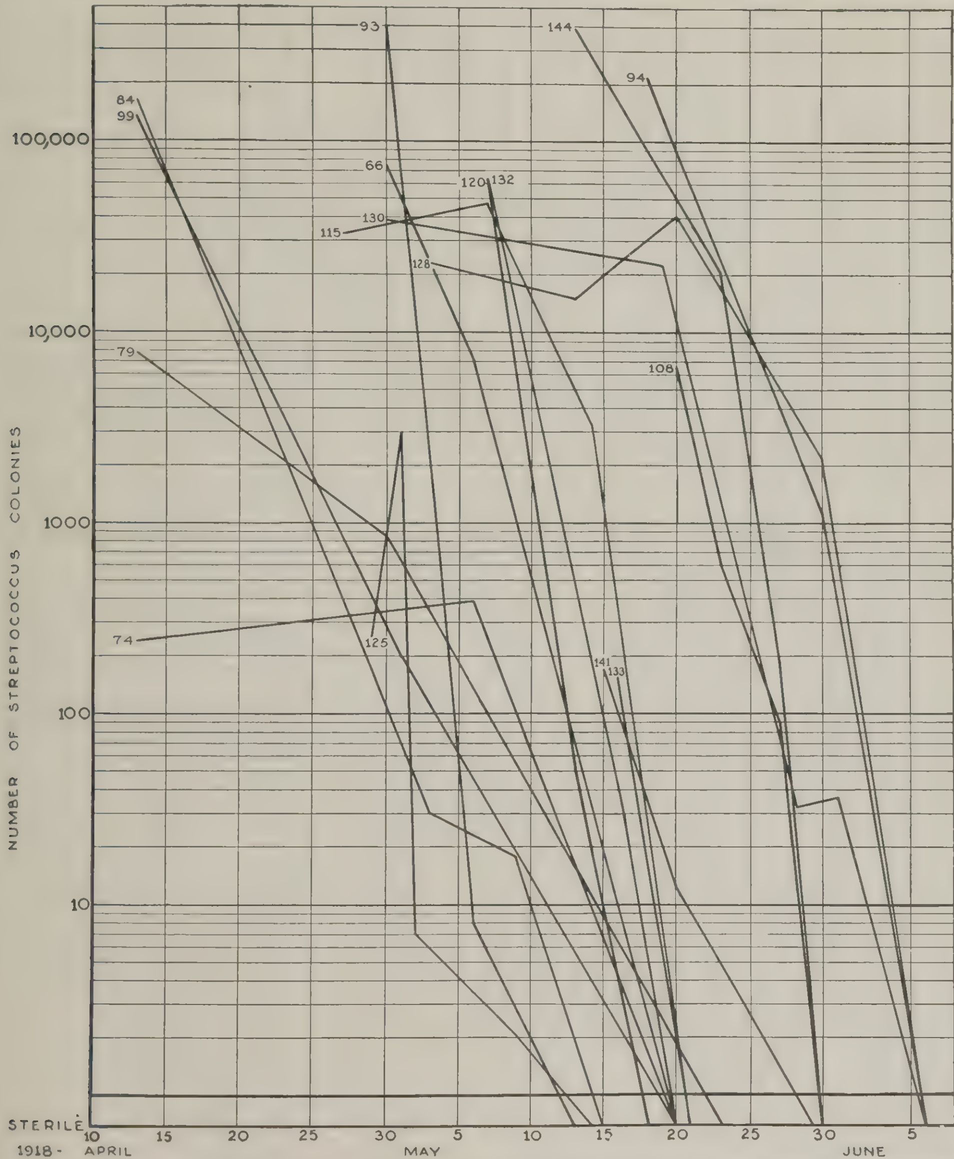


CHART LX.—Graphic illustration of the elimination of hemolytic streptococcus from empyema cavities during disinfection with Dakin's solution at Camp Lee, Va.

stances after sterility was apparently attained, the bacteria were again found in numbers even larger than those obtained on any previous examinations.

Notwithstanding the apparent confusion of the lines in this chart, it is instructive to note that the general slope of the descending lines does not vary to any considerable extent. It is equally evident, however, that the course of

disinfection was far from uniform in the majority of these cases, since there are great variations in most of the curves. There are many possible explanations of these wide fluctuations. One is undoubtedly concerned with the bacteriological technique employed in the study. Some of the samples were unquestionably contaminated with secretions retained between the drainage tube and sinus wall where they were protected from the action of Dakin's solution. It was extremely difficult to avoid this secretion when the sinuses were long, narrow, and tortuous.

There are numerous ways, of course, in which disinfection may be retarded or thwarted. Some of these have been mentioned in the early part of this chapter. Occasionally foreign bodies, such as drainage tubes, pieces of rubber dam, or other bits of dressings, have nullified attempts at disinfection by harboring organisms in places inaccessible to the antiseptic. Necrosis and osteomyelitis of a rib have discharged infected material into cavities, causing repeated reinfections of cases which would otherwise progress favorably. Some of the wide fluctuations in the chart were due to the rupture of a small encapsulation which was not drained at the time of the operation. This has occurred frequently after the cavities were practically sterile. Apparently the solution of the fibrinous linings of the cavities by Dakin's solution opened up the secondary pus pockets.

The chart which has been under consideration gives the totals of the colonies on the plates. Since the bacteria responsible for the infection in all the cases at Camp Lee were hemolytic streptococci, it is important to study the effect of antiseptic treatment on these bacteria. Chart LX has been prepared for this purpose.

Chart LX includes only those cases in which the streptococci were eliminated before the patients were transferred from Camp Lee. They were, therefore, continously under the same care and subjected to a uniform method of study. The figures associated with the curves are the case numbers of the patients, and serve as references to the condensed tables (45, 46, 47) of the cases at the end of this chapter.

The chart is much less confusing than the preceding one, because these cases were selected and chance contaminations with stray organisms were ignored. Attention was directed only to the streptococcus. The chart is of interest because it demonstrates that under favorable conditions the surgeon may expect to sterilize the cavities within a reasonably short interval. A corollary to such a conclusion would be that when disinfection is not accomplished readily, some condition within the thorax or in the chest wall or some error in the technique employed in the use of the antiseptic is responsible.

From this point of view, Carrel-Dakin technique serves not merely as a useful measure to promote cure, but if it be controlled by quantitative bacteriological examinations may call attention to complications which might otherwise be overlooked. Failure to attain sterilization of the cavity within a reasonable period of time should lead to a study of the case in order to discover the conditions causing the constant reinfection.

THE RELATION BETWEEN STERILIZATION AND WOUND CLOSURE.

The preceding review of the bacteriological methods leads to a consideration of the application of these methods to a study of disinfection and wound closure. In the section on the effects of sodium hypochlorite antisepsis on healing, reference was made to a smaller yet more intensively studied group of cases. This smaller group includes 102 cases studied at Camp Lee.[6] They were treated in the same manner as the larger series but are subject to more

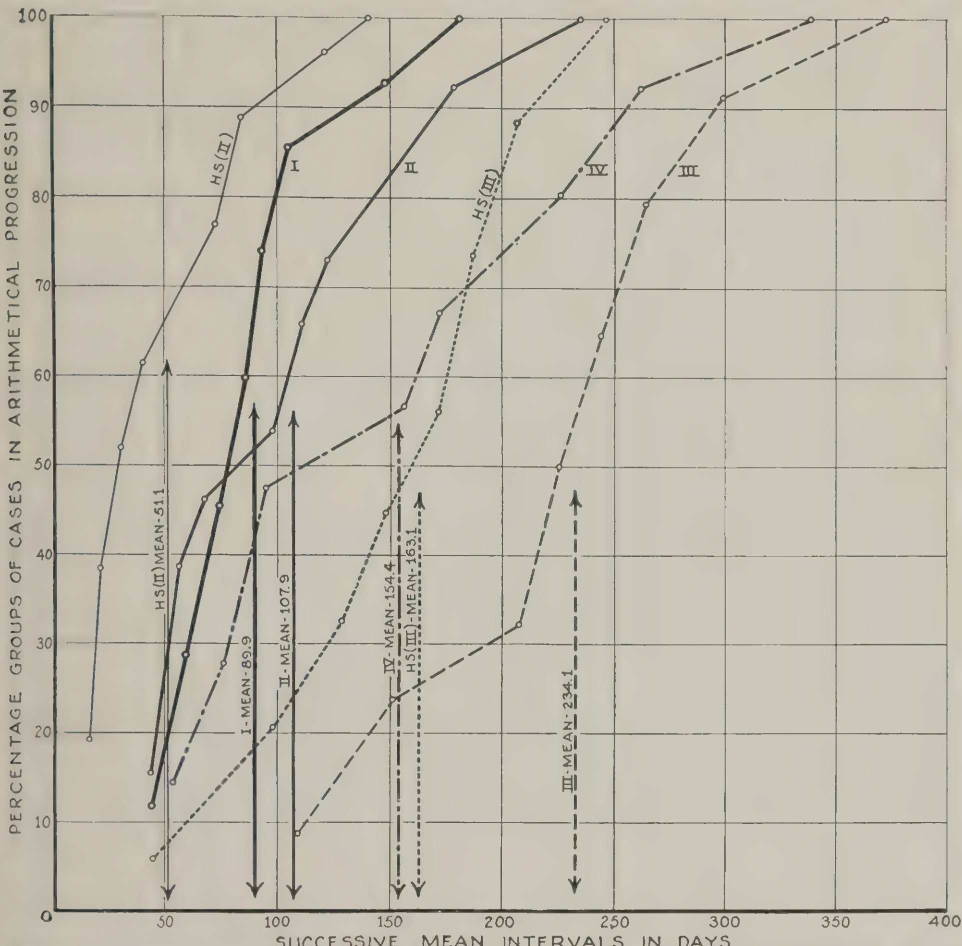


CHART LXI.—Successive mean intervals between first operation and closure of the thoracic wound, Camp Lee, Va. Curve I, simple drainage (see Table 39). Curve II, prompt treatment with Dakin (see Table 40). Curve III, delayed treatment with Dakin (see Table 42). Curve IV, simple drainage, including subsequent treatment with Dakin; this curve is a composite of Curves I and III (see Table 44). Curve HS (II), hemolytic streptococci eliminated among II (see Table 41). Curve HS (III), hemolytic streptococci eliminated among III (see Table 43).

careful analysis since the requisite data are complete. Careful bacteriological studies were made in all cases in which Dakin's solution was used for irrigation, so that the progress of disinfection can be followed in each case from the beginning of this treatment until the wound had healed. The methods of analysis are similar to those employed in the larger series, and the cases have been grouped according to the treatment. The intervals between the operations and the final healing of the wounds have been determined and the mean successive intervals estimated for each group. These intervals have been charted in Chart LXI, so that they may be compared with those in the previous series.

The first group (Curve I) contains 42 cases in which no antisepsis was applied during the postoperative care. Among these there were three recurrences appearing a considerable time after the wound healed. The second group (Curve II) includes 26 cases in which Dakin's solution was used for irrigation at the time dressings were changed, and also for intermittent instillations between dressings at intervals of from one to three hours. This treatment was begun within a short time after the first operation. In this group there was one recurrence after the wound had closed. The third group (Curve III) comprises 34 cases in which the postoperative treatment was simple drainage, followed after an interval of from one to four months by antiseptic treatment with Dakin's solution. The procedure was the same as that used in the second group. There were two recurrences after the thoracic wound had healed. The mean period of wound closure for each of these groups is indicated by a vertical line on each of the respective curves. Curves I and II resemble the corresponding curves in Chart LVIII which was based on a much larger number of cases. In Chart LVIII, however, Curves I and II intersect at a shorter interval after operation at a time when a smaller percentage of the cases had healed. It is the intersection of these two curves that demands study in seeking an explanation of the apparent efficiency of simple drainage.

If the whole series of 102 cases is again reviewed, it may be divided into two groups. In one of these groups Dakin's solution was promptly used after operation. This group of 26 cases is represented by Curve II. The other group includes those cases, 76 in number, that were, at least for some time, treated by simple drainage. This second group is shown as Curve IV. Of these cases, 25 healed within 90 days, or before the time after operation when cases usually pass from the more acute to the more chronic condition. Seventeen additional cases had progressed to a point where the cavity was obliterated and the thoracic wound had contracted to a small sinus not adjudged to require energetic treatment. There were 34 cases that had not made such progress. They were still draining profusely and presented cavities of varying but considerable size. These cases were then treated with Dakin's solution of sodium hypochlorite. This change in treatment and the time at which it took place are of such importance that the data have been presented in graphic form in Chart LXII. Here it is shown that the transfers were most frequent in the period between 60 to 90 days after operation, and that in 27 of the 34 cases, nearly 80 per cent, simple drainage had preceded antiseptic treatment for at least two months. The mean interval after operation when antiseptic treatment was begun was 90 days, whereas in the cases promptly treated it was nine days. The 90-day interval closely approximates that at which empyema cases become chronic, that is, when the production of healthy granulation tissue is checked by cicatricial changes, and the healing process becomes indolent. The contractions of the newly formed tissues at this stage militate against free drainage of any considerable cavity that may persist, and also restrict the thoroughness with which antiseptic treatment can be applied. It is not surprising, therefore, to find that, taken collectively, these transferred cases proved more refractory than those that did well under simple drainage or that received a more prompt antiseptic treatment.

It should be stated that in many of the transferred cases the adverse conditions following a protracted septic inflammation had to be corrected by a dilatation of the sinus or a second operation, before treatment of the cavity with Dakin's solution could be efficiently carried out.

To return to a further consideration of Chart LXI, Curve IV necessarily lies between Curves I and III, since it is based on the cases represented in these curves. Curve IV, which lies considerably to the right of Curve II, represents the cases promptly treated with Dakin's solution. In the aggregate, the cases that received prompt Dakin treatment closed in a shorter period of time than those in which this treatment was delayed or entirely omitted.

Since the purpose of antiseptic treatment is the elimination of the infecting organisms, bacteriological studies relative to the progress of disinfection become

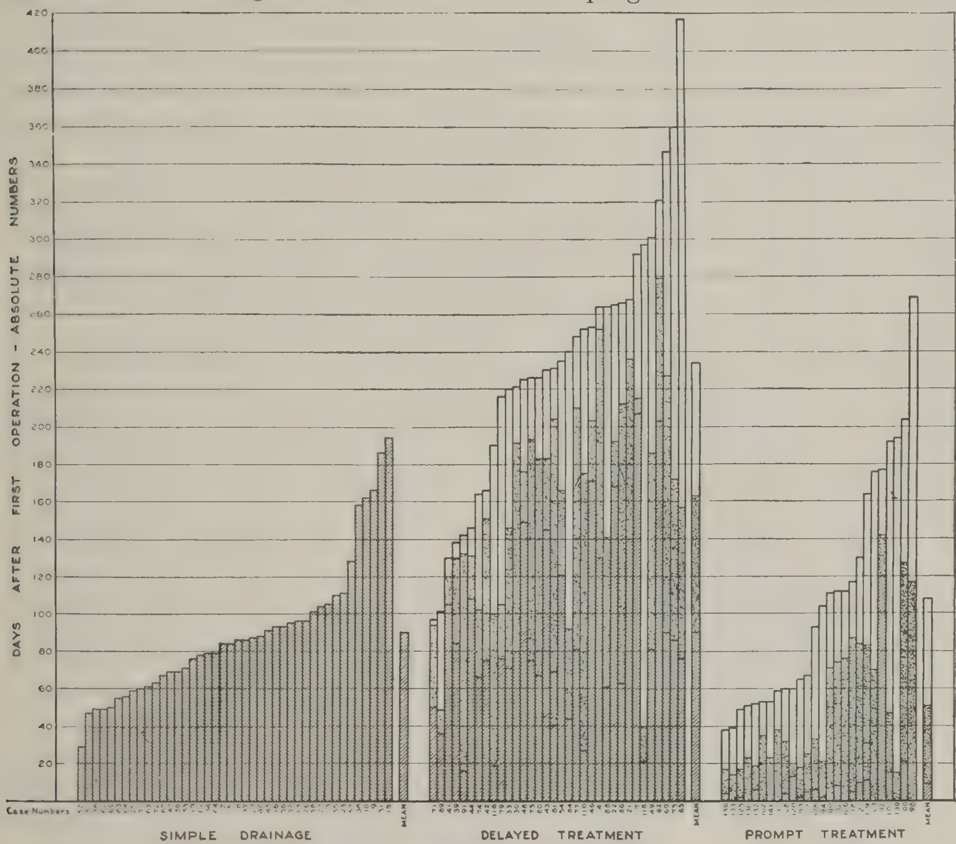


CHART LXII.—Graphic illustration of Camp Lee cases showing the effect of antisepsis with neutral solution of sodium hypochlorite on the healing of empyema wounds after the first operation. The height of the upright columns indicates the number of days which elapsed in each case before complete and final closure of the wound. At the extreme left is a series of 42 cases which healed under simple tube drainage without antisepsis (see Table 47). In the center is a series of 34 cases first treated by simple drainage and subsequently transferred to irrigations with Dakin's solution (see Table 45). The time of simple drainage is represented by the cross-hatched portion of the column after which the cases were transferred to antisepsis. The time which elapsed before healing by antisepsis is represented by the dotted and white portion, the dotted part representing the interval when streptococci were still present and the white part when they were no longer found in the cultures of the wounds. At the extreme right is a series of 26 cases treated throughout their course by irrigations (see Table 46). The average mean period is represented by the column at the right of each series.

of importance in the further analysis of these cases. There are no such data on the cases treated solely by simple drainage. Of the 42 cases in this group there are no bacteriological data for 18. Of the remaining 24, three showed pneumococci, and the rest hemolytic streptococci.

Bacteriological data are available for the two groups treated with Dakin's solution. Without exception they were associated with hemolytic streptococci.

In addition to these data the approximate dates on which the streptococci were finally eliminated from the cavities are known. The distribution of the

intervals between the operations and the elimination of the streptococci from the wounds in the cases represented in Curves II and III has been charted. These curves are marked "HS" and the mean intervals indicated by vertical lines.

It is of practical interest to note that the mean intervals of time between the elimination of the hemolytic streptococcus and closure of the wound in the two groups in which Dakin's solution was used show a difference of only two weeks, notwithstanding a difference of approximately four months in the respective mean intervals of wound closure. In the Dakin-prompt cases the mean time for streptococcus elimination was 51.1 days; for wound closure 107.9 days. The difference between these is 56.8 days. The mean time for the elimination of streptococci in the Dakin-delayed cases was 163.1 days; for wound closure 233.8 days. Here the difference is 70.7 days.

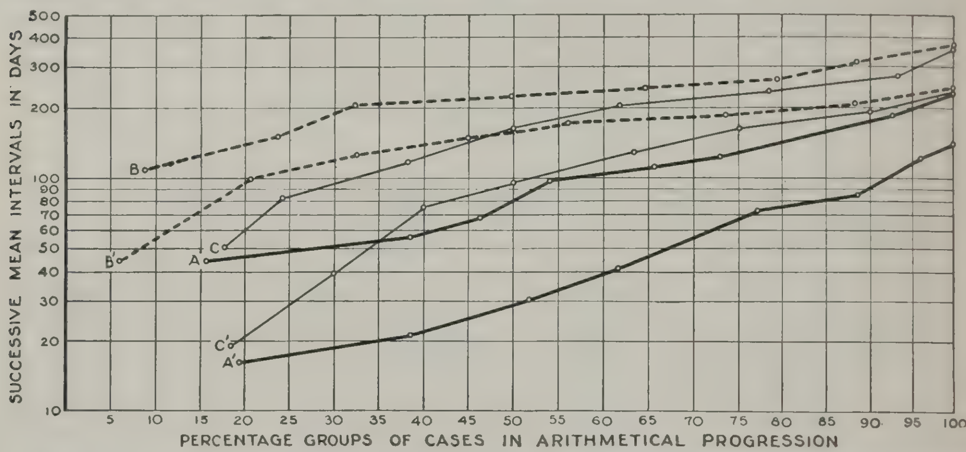


CHART LXIII.—Graphic illustration of the parallelism between the disappearance of hemolytic streptococci from wounds and closure of the cavities of cases at Camp Lee, Va. Curves A, B, and C are for wound closure and A', B', C' for elimination of hemolytic streptococci. Curves A and A' represent the effect of prompt treatment with Dakin's solution of sodium hypochlorite. Curves B and B' delayed treatment, and curves C and C' all cases. The successive mean intervals are drawn on a logarithmic scale.

From these data it appears justifiable to conclude that the chief hindrance to closure of the wound was a persistent infection with streptococci, and that the use of Dakin's solution was markedly helpful in overcoming this infection.

There remains for consideration the question as to whether this relation between the mean intervals for the elimination of the streptococcus and wound closure, which are so nearly identical after the use of Dakin's solution in these two groups, expresses the relation which exists between the intervals throughout the series of cases. Chart LXIII has been prepared on a logarithmic scale to illustrate the ratios between these intervals throughout the series.

There is a very close parallelism between the curves representing the elimination of the streptococcus and wound closure. This is most striking in the curves for delayed treatment, but is clearly evident in those for prompt treatment in spite of a slight lag in the first half of the cases. This chart shows that this relation between sterilization and wound closure is nearly uniform and that it is justifiable to extend the deductions based upon a comparison of the means to all parts of the series.

The figures upon which the curves in Charts LXI, LXII, and LXIII, are based are given in Tables 39 to 47.

It will be noticed that in grouping the cases at Camp Lee into those in which treatment was prompt and those in which it was delayed, a few cases appear to be misplaced. The decision in these cases was based on the character of the operation. Those cases in which the operation was done with a view to the introduction of Carrel tubes distributed to all parts of the cavity are included in the Dakin-prompt class even when the antiseptic applications did not immediately follow the operation. The number of these exceptional cases is not large enough to greatly influence the deductions which may be drawn from the data taken collectively.

TABLE 39.[a]—*Wound closure after the first operation among cases treated by simple drainage, distributed according to the successive mean periods—Camp Lee, Va.*

Distribution.								
Cases.					Mean periods in days.			
Total number.	Successive groups.			Per cent of total in third group.	Successive groups.			Average mean period.
	First.	Second.	Third.		Third.	Second.	First.	
42	25	12	5	11.90	44.0	54.25	67.48	89.9
			7	16.67	59.1			
		13	7	16.67	74.7	79.70		
			6	14.29	85.8			
	17	11	6	14.29	94.0	99.55	122.9	
			5	11.90	106			
		6	3	7.14	149	165.7		
			3	7.14	182			

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

TABLE 40.[a]—*Wound closure after first operation among cases promptly treated with neutral solution of sodium hypochlorite, distributed according to the successive mean periods—Camp Lee, Va.*

Distribution.								
Cases.					Mean periods in days.			
Total number.	Successive groups.			Per cent of total in third group	Successive groups.			Average mean period.
	First.	Second.	Third.		Third.	Second.	First.	
26	14	10	4	15.4	44.3	51.4	60.5	107.9
			6	23.1	56.2			
		4	2	7.7	68.0	83.3		
			2	7.7	98.5			
	12	5	3	11.5	111.7	116.4	163.2	
			2	7.7	123.5			
		7	5	19.2	180.6	196.6		
			2	7.7	236.5			

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

TABLE 41.[a]—*Elimination of hemolytic streptococci after the first operation among cases promptly treated with neutral solution of sodium hypochlorite, distributed according to the successive mean periods—Camp Lee, Va.*

Distribution.								
Cases.					Mean periods in days.			
Total number.	Successive groups.			Per cent of total in third group.	Successive groups.			Average mean period.
	First.	Second.	Third.		Third.	Second.	First.	
26	16	10	5	19.2	16.2	18.7	24.8	51.1
			5	19.2	21.2			
		6	3.5	13.5	30.7	35.0		
			2.5	9.6	41.0			
	10	7	4	15.4	73.0	78.0	93.2	
			3	11.5	84.7			
		3	2	7.7	122	129		
			1	3.9	142			

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

TABLE 42.[a]—*Wound closure after the first operation among cases treated with neutral solution of sodium hypochlorite after a period of simple drainage, distributed according to the successive mean periods—Camp Lee, Va.*

Distribution.								
Cases.					Mean periods in days.			
Total number.	Successive groups.			Per cent of total in third group.	Successive groups.			Average mean period.
	First.	Second.	Third.		Third.	Second.	First.	
34	17	8	3	8.8	109.3	135.5	180.5	234.1
			5	14.7	151.2			
		9	3	8.8	208.7	220.6		
			6	17.6	226.5			
	17	10	5	14.7	245.6	255.5	287.7	
			5	14.7	265.4			
		7	4	11.8	302.8	333.6		
			3	8.8	374.7			

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

TABLE 43.[a]—*Elimination of hemolytic streptococci after the first operation among cases treated with Dakin's solution of sodium hypochlorite, after a period of simple drainage, distributed according to the successive mean periods—Camp Lee, Va.*

Distribution.								
Cases.					Mean periods in days.			
Total number.	Successive groups.			Per cent of total in third group.	Successive groups.			Average mean period.
	First.	Second.	Third.		Third.	Second.	First.	
34	15	7	2	5.9	44.5	83.1	112.7	163.1
			5	14.7	98.6			
		8	4	11.8	128.3	138.5		
			4	11.8	148.8			
	19	10	4	11.8	172.3	181.7	202.9	
			6	17.6	188.0			
		9	5	14.7	208.8	226.4		
			4	11.8	248.5			

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

TABLE 44.[a]—*Wound closure after the first operation among cases treated by simple drainage, and including those subsequently receiving Carrel-Dakin treatment, distributed according to the successive mean periods.—A composite table of cases in Tables 39 and 42—Camp Lee, Va.*

<table>
<tr><th colspan="9">Distribution.</th></tr>
<tr><th colspan="5">Cases.</th><th colspan="4">Mean periods in days.</th></tr>
<tr><th rowspan="2">Total number.</th><th colspan="3">Successive groups.</th><th rowspan="2">Per cent of total in third group.</th><th colspan="3">Successive groups.</th><th rowspan="2">Average mean period.</th></tr>
<tr><th>First.</th><th>Second.</th><th>Third.</th><th>Third.</th><th>Second.</th><th>First.</th></tr>
<tr><td rowspan="8">76</td><td rowspan="4">43</td><td rowspan="2">21</td><td>11</td><td>14.5</td><td>53.1</td><td rowspan="2">63.8</td><td rowspan="4">85.2</td><td rowspan="8">154.4</td></tr>
<tr><td>10</td><td>13.2</td><td>75.6</td></tr>
<tr><td rowspan="2">22</td><td>15</td><td>19.7</td><td>94.6</td><td rowspan="2">105.6</td></tr>
<tr><td>7</td><td>9.2</td><td>157.9</td></tr>
<tr><td rowspan="4">33</td><td rowspan="2">18</td><td>8</td><td>10.5</td><td>173.3</td><td rowspan="2">203.1</td><td rowspan="4">244.6</td></tr>
<tr><td>10</td><td>13.2</td><td>227.0</td></tr>
<tr><td rowspan="2">15</td><td>9</td><td>11.8</td><td>263.6</td><td rowspan="2">294.3</td></tr>
<tr><td>6</td><td>7.9</td><td>340.5</td></tr>
</table>

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.

TABLE 45.[a]—*Camp Lee cases (total, 34) treated with Dakin's solution of sodium hypochlorite following a period of simple drainage.*

[The table shows the intervals between the operation, the beginning of antisepsis, the sterilization of the wounds, and final healing. The data are used directly without modification in Chart LXII.]

Case No.[b]	First operation.	Antisepsis begun.		Hemolytic streptococci absent.		Wound closed.	
	1918	1918	Days after operation.	1918	Days after operation.[c]	1918–19	Days after operation.[d]
4	Jan. 3	May 13	130	Sept. 12	252	Sept. 24	264
17	Jan. 18	Aug. 13	207	Aug. 21	215	Nov. 6	292
21	Jan. 3	May 23	140	Aug. 27	236	Sept. 28	268
22	Jan. 5	June 22	168	July 16	192	Sept. 27	265
30	Jan. 18	Apr. 8	80	July 23	191	Aug. 27	221
33	Feb. 14	Apr. 26	71	July 11	146	Sept. 22	220
39	Feb. 2	Apr. 27	84	June 12	130	June 20	138
41	Jan. 15	Apr. 30	105	May 15	120	May 25	130
42	Jan. 26	Apr. 11	75	June 27	151	July 11	166
43	Jan. 9	June 3	145	July 11	183	Aug. 27	230
44	Jan. 10	Apr. 28	108	May 21	131	June 6	146
46	Jan. 15	July 5	171	Aug. 6	203	Sept. 25	253
48	Jan. 14	June 12	149	July 11	176	Aug. 27	225
49	Jan. 18	Apr. 9	81	July 25	186	Nov. 15	301
54	Jan. 31	June 3	121	July 16	166	Sept. 23	235
65	Feb. 12	Apr. 29	76	July 19	157	Apr. 5	417
69	Jan. 28	Apr. 25	90	Sept. 22	227	Dec. 26	347
71	Feb. 7	Mar. 29	50	May 12	94	May 15	97
73	Feb. 1	Apr. 28	86	July 24	172	[e]Jan. 26	360
74	Feb. 7	Apr. 14	66	May 20	102	July 21	164
75	Feb. 9	Apr. 25	75	Aug. 21	193	Sept. 24	226
77	Feb. 5	Apr. 27	81	Sept. 3	210	Oct. 11	248
79	Feb. 7	Apr 24	76	May 23	105	Sept. 11	216
80	Feb. 19	Apr. 27	67	Aug. 21	183	Oct. 3	226
81	Feb. 20	Apr. 30	69	Sept. 12	204	Oct. 9	231 R
82	Feb. 12	Sept. 3	203	Nov. 18	279	[e]Jan. 7	321
84	...do....	Mar. 28	44	May 15	92	Oct. 10	240
86	Feb. 25	Apr. 27	63	Sept. 23	212	Nov. 16	266 R
88	...do....	...do....	61	July 16	141	...do....	264
89	Mar. 1	Apr. 6	36	Apr. 18	49	July 11	101
91	Mar. 9	Mar. 25	16	July 19	132	July 29	142
110	Mar. 31	Apr. 27	27	Sept. 22	175	Dec. 8	252
115	Apr. 6	...do....	21	May 16	40	[e]Jan. 8	297
116	Apr. 8	...do....	19	July 17	100	Oct. 15	190
Average mean	....	....	90.0	....	163.1	....	234.1

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.
[b] The cases are listed chronologically according to the dates af admission to the base hospital.
[c] These intervals have been used to compute the successive mean periods in Table 43.
[d] These intervals have been used to compute the successive mean periods in Table 42.
[e] 1919. R=Recurrence after healing.

TABLE 46.[a]—*Camp Lee cases (total, 26) treated promptly by neutral solution of sodium hypochlorite.*

[This table gives the dates of the operations, the day on which antisepsis was begun, the dates of sterilization, and the day on which the wounds were considered healed. The intervals have been calculated. The time intervals have been used directly in the preparation of Chart LXII.]

Case No.[b]	First operation.	Antisepsis begun.		Hemolytic streptococci absent.		Wound closed.	
	1918	1918	Days after operation.	1918	Days after operation.[c]	1918	Days after operation.[d]
92 [e]	Mar. 3	July 1	120	July 23	142	Aug. 27	177
93	Apr. 25	Apr. 27	2	May 13	18	July 1	67
94	May 16	May 18	2	June 6	21	July 29	104
97	Mar. 7	Mar. 15	8	May 20	74	July 27	112
98	Mar. 21	Mar. 21	0	July 16	117	Dec. 15	269
99	Mar. 9	Mar. 9	0	May 20	71	June 29	111
100	Mar. 11	Apr. 1	21	July 16	127	Oct. 1	204
101	Mar. 23	Apr. 7	15	May 9	47	...do....	192
102	Mar. 22	Mar. 22	0	Apr. 26	35	May 14	53
103	Mar. 14	Mar. 14	0	May 23	70	Sept. 6	176
106	June 6	June 6	0	Aug. 21	76	Sept. 27	112
108	Apr. 28	May 2	4	June 6	32	June 27	60
111	Apr. 12	Apr. 12	0	May 20	38	June 10	59
118	May 7	May 12	5	Aug. 2	87	Aug. 27	117
117	...do....	...do....	5	June 1	25	July 15	69
119	Apr. 29	May 10	11	July 21	83	Oct. 10	164
120	Apr. 28	May 11	13	May 18	20	June 27	60 R
121	May 7	May 17	10	July 30	84	Sept. 14	130
125 [f]	Apr. 27	Apr. 29	2	May 14	17	June 15	49
128	May 4	May 10	6	June 6	33	Aug. 5	93
130	May 22	May 22	0	...do....	15	Dec. 22	194
132	May 1	May 7	6	May 20	19	June 22	52
133	May 7	...do....	0	May 21	14	June 15	39
136	May 3	...do....	4	May 24	17	June 10	38
138	May 14	May 14	0	June 6	23	July 4	51
141	May 6	May 6	0	May 29	23	June 28	53
Average mean	....	....	9.0	....	51.1	....	107.9

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.
[b] The cases are listed chronologically according to the dates of admission to the base hospital.
[c] These intervals have been used to compute the successive mean periods in Table 41.
[d] These intervals have been used to compute the successive mean periods in Table 40
[e] Treatment with Dakin's solution was attempted at intervals, beginning soon after the operation, but had to be stopped because of a large pleurobronchial communication. The treatment could not be used intensively until 120 days after the first operation.
[f] Treated with dichloramine-T, 5 per cent in chlorcosane, throughout, except for an occasional irrigation with Dakin's solution at the time dressings were changed.
R = Recurrence after healing.

TABLE 47.[a]—*Camp Lee cases (total, 42) treated by simple drainage without antisepsis.*

[This table gives the interval in days before wound closure. Chart LXII shows these intervals graphically.]

Case No.[b]	First operation.	Wound closed.		Case No.[b]	First operation.	Wound closed.	
	1918	1918	Days after first operation.[c]		1918	1918	Days after first operation.[c]
2	Jan. 1	Mar. 26	84	45	Jan. 14	Apr. 15	91
3	...do....	Apr. 16	105	47	Jan. 18	Mar. 28	69
5	Jan. 16	Apr. 10	84	50	Jan. 15	Mar. 25	69
9	Jan. 5	June 26	166	51	Jan. 28	Mar. 16	47
10	Jan. 4	June 15	162	52	Jan. 14	Feb. 12	29
13	Jan. 10	Apr. 16	96	53	Jan. 13	Mar. 25	71
15	Jan. 5	July 19	194	55	Feb. 4	May 25	110
16	Jan. 7	Apr. 5	93	56	Jan. 17	Apr. 20	93 R
18	Jan. 5	Mar. 27	86	57	Feb. 23	July 1	128
19	Jan. 15	May 1	76	58	Jan. 19	Apr. 30	101
23	Jan. 5	Apr. 26	111	60	Jan. 26	Mar. 19	52
24	Jan. 2	May 16	104	61	Feb. 7	Apr. 26	78
25	Jan. 9	Mar. 9	59	62	Feb. 13	Apr. 5	51
26	Jan. 1	Apr. 7	96	63	Feb. 20	Apr. 22	61
27	Jan. 2	Mar. 30	87	64	Jan. 29	Apr. 18	79
31	...do....	July 6	186 R	67	Feb. 7	Apr. 15	67
32	Jan. 14	Apr. 19	95	68	Feb. 13	Apr. 10	56
34	Jan. 23	Apr. 12	79	70	Feb. 11	Apr. 12	60
36	Feb. 23	Apr. 15	51	72	...do....	Apr. 15	63
37	Jan. 14	Apr. 10	86	83	Feb. 20	Apr. 16	55
38	Jan. 22	June 30	158				
40	Jan. 23	Apr. 21	88 R	Average mean	....	....	89.9

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.
[b] The cases are listed chronologically according to the dates of admission to the base hospital.
[c] These intervals have been used to compute the successive mean periods in Table 39.
R = Recurrence after healing.

THE EFFECTS OF ANTISEPSIS WITH NEUTRAL SOLUTION OF SODIUM HYPOCHLORITE ON THE FINAL CONDITION OF PATIENTS AFTER DISCHARGE.

At the beginning of this section reference was made to a statistical study of cases based upon the replies to follow-up letters. These replies give information concerning ability to work, dyspnea, pain, persistent cough, and symptoms referred to the heart by the man himself. The reports upon work may be divided into the following three classes: Heavy work, light work, and no work. These, together with the four symptoms, make seven simple categories. They may, however, be associated in pairs, in threes, fours, or even fives. For example, a man may report that he is doing heavy work, but has pain, or pain and dyspnea, or pain, dyspnea and cough. He may state that he has pain, dyspnea, a persistent cough, palpitation of the heart, and is unable to work.

When the possible permutations of these data have been listed and the number of cases under each heading ascertained in respect of two or more groups of cases, selected because of some specified difference in the histories, it is possible to calculate the probabilities as to whether the divergences revealed by the aggregate of follow-up data depart in any marked degree from that which would have resulted had the selection been made at random. The method which has been used to calculate these probabilities is known as the chi-square test. This mode of mathematical analysis has been applied to the three groups of cases already studied regarding wound closure, namely, (1) those in which the postoperative treatment was simple drainage, (2) those in which Dakin's solution was used with a partial Carrel technique, and (3) those in which the full technique was followed.[a]

Applying this test to a comparison of simple drainage with partial Dakin treatment in so far as work and symptoms are concerned, the equations $X^2 - 83.98$ and $P = 0.007$ were obtained. This means that the data as submitted would have arisen on the basis of chance seven times in 1,000 trials. In other words, the partial Dakin treatment gave significantly better results in so far as work and symptoms were concerned than simple drainage.

Comparing in the same way simple drainage with full Dakin treatment, the expressions were $X^2 = 88.02$, $P = 0.0005$. This again means that this antiseptic treatment was significantly better than simple drainage.

A comparison of the partial with the full Dakin treatment, also regarding work and symptoms, gave: $X^2 - 66.74$, $P - 0.08$. Here the results favor the full technique, but the degree of superiority is of a somewhat lower order than that revealed in the previous comparisons.

From these results it appears safe to conclude that Dakin's solution when used with the full Carrel technique gave better ultimate results than when it was used less intensively and that either use of the solution was followed by a better condition of the patient than when simple drainage without antisepsis was the postoperative treatment.

The comparisons were carried further, with the following results: Partial Dakin treatment gave better results than simple drainage regarding work, pain and probably, though not quite certainly, dyspnea. In so far as cough and heart symptoms were concerned, there was no significant difference.

[a] The actual calculations were kindly undertaken by Prof. Raymond Pearl, of the Johns Hopkins University.

Full Carrel-Dakin treatment gave better results than simple drainage regarding dyspnea and probably, though not quite certainly, work, pain, cough, and heart symptoms.

It will be recalled that preceding studies have shown that many of the cases which eventually received treatment with Dakin's solution were of a more refractory nature than those which, when simply drained, healed within a reasonable length of time. It would be of value to know whether this difference in the readiness with which cases healed was associated with differences in the pathology of the cases as indicated by the diseases preceding empyema and the organisms present in the pleural exudate. The actual data bearing on this question will be found in tables at the end of this chapter. But these data also were submitted to the chi-square test, because this made it possible to study permutations which would obscure the meaning if presented in tabular form only and would yield very complex charts.

The antecedent diseases chosen for this purpose were measles, influenza, lobar pneumonia, and bronchopneumonia. These embrace practically all of the cases. The infecting organisms were classed as pneumococci, diplococci, streptococci, staphylococci, and "unknown." In this problem the data were considered only in pairs, for there was for each case but a single antecedent disease and a single infecting organism. In some instances there were too few of a given combination to have statistical significance; for example, there was no case of empyema following lobar pneumonia and treated with Dakin-full technique in which staphylococci were found in the exudate. There were, however, 16 useful categories into which the data concerning antecedent diseases and infecting organisms could be grouped under the headings of simple drainage, Dakin-part, and Dakin-full treatment.

Applying the chi-square test to these data, it resulted in showing a marked degree of selection. The expressions indicating this were as follows: Simple drainage compared with partial Dakin, $X^2=111.975$, $P=0$; simple drainage compared with Dakin-full technique, $X^2=26.523$, $P=0.022$; Dakin-part compared with Dakin-full, $X^2=31.90$, $P=0.003$.

This method of statistical analysis does not offer any medical interpretation of the results, but merely shows that the distribution of the cases in respect to the mode of treatment was not fortuitous but was influenced in the aggregate by the pathology of the cases.

As a final summing up of all the foregoing studies it is reasonable to conclude that the more complex and refractory cases were the ones which eventually came under antiseptic treatment with Dakin's solution, and that this treatment proved of very marked benefit.

TABLE 48.[a]—*Data on symptoms used in applying the chi-square test.*

	Simple drainage.	Dakin-part.	Dakin-full.		Simple drainage.	Dakin-part.	Dakin-full.		Simple drainage.	Dakin-part.	Dakin-full.
w	94	88	24	lw-d-p	67	36	13	w-d-p-c-h	0	0	0
lw	36	16	11	lw-d-c	8	4	1	lw-d-p-c-h	2	0	3
Ow	7	9	2	lw-d-h	4	4	1	Ow-d-p-c-h	1	2	0
d	6	8	6	Ow-d-p	8	8	3	w-d-c-h	2	0	2
p	9	9	8	Ow-d-c	0	3	0	lw-d-c-h	0	1	0
c	0	3	1	Ow-d-h	2	0	0	Ow-d-c-h	1	0	0
h	7	6	3	w-p-c	16	6	3	lw-p-c-h	1	0	0
w-d	22	19	8	w-p-h	3	3	0	Ow-p-c-h	0	1	0
w-p	83	55	14	lw-p-c	28	12	3	d-p	8	18	7
w-c	6	8	0	lw-p-h	13	10	2	d-c	2	2	1
w-h	0	1	0	Ow-p-c	4	2	0	d-h	0	0	1
lw-d	22	11	1	Ow-p-h	2	1	0	p-c	9	5	0
lw-p	85	35	15	w-c-h	0	0	0	p-h	2	2	0
lw-c	6	3	0	lw-c-h	0	1	0	c-h	0	0	0
lw-h	5	0	0	Ow-c-h	0	0	0	d-p-c	2	10	2
Ow-d	4	6	0	w-d-p-c	10	3	2	d-p-h	1	1	2
Ow-p	13	10	3	w-d-p-h	3	1	0	d-c-h	0	1	0
Ow-c	0	1	0	lw-d-p-c	25	12	0	d-p-c-h	0	0	0
Ow-h	2	1	1	lw-d-p-h	10	5	3	p-c-h	1	1	2
w-d-p	34	34	13	Ow-d-p-c	3	5	2				
w-d-c	3	6	1	Ow-d-p-h	1	1	0		684	488	166
w-d-h	1	0	2								

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.
w, heavy work; lw, light or limited work; Ow, no work; d, dyspnea; p, pain; c, persistent cough; h, heart symptoms.

TABLE 49[a].—*Data on antecedent diseases and associated microorganisms used in applying the chi-square test.*

	Simple drainage.	Dakin-part.	Dakin-full.		Simple drainage.	Dakin-part.	Dakin-full.		Simple drainage.	Dakin-part.	Dakin-full.
P-S	226	185	58	B-i	0	0	0	M-p	12	1	4
P-p	160	72	25	B-?	35	25	14	M-dp	e 5	e 4	e 1
P-dp	a 13	a 4	a 4	I-S	110	90	31	M-Sa	e 3	e 1	e 0
P-Sa	a 8	a 4	a 0	I-p	56	74	26	M-i	0	0	0
P-i	b 0	b 1	b 0	I-dp	4	8	1	M-?	52	9	8
P-?	b 172	b 54	b 30	I-Sa	d 6	d 1	d 0	?-S	3	1	1
B-S	60	91	19	I-i	d 0	d 1	d 0	?-p	1	1	0
B-p	c 26	c 12	c 11	I-?	38	48	12				
B-dp	c 4	c 3	c 0	M-S	54	40	7		1,050	731	252
B-Sa	c 2	c 1	c 0								

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.
P, lobar pneumonia; B, bronchopneumonia; I, influenza, M, measles; S, streptococcus; p, pneumococcus; dp, "diplococcus"; Sa, staphylococcus; i, influenza bacillus.
a, a, b, b, etc., indicate that the figures in these were combined, respectively, in using these data for making the chi-square test.

A COMPARISON OF THE CLOSED AND OPEN METHODS IN THE TREATMENT OF EMPYEMA.

Following the institution of aspiration in the treatment of empyema as the immediate remedial measure to be followed by a subsequent thoracotomy, various modifications in treatment were adopted. Chief among these was the instillation of either Dakin's solution, formalin uncombined or in combination with glycerin, or a combination of all of these, through a catheter inserted in a punctured wound in the chest wall. The exudate was aspirated through the catheter and the antispetic was introduced into the cavity. When exudate was no longer formed in large quantities and cultures of the cavity were sterile the catheter was removed and the puncture wound was allowed to heal.

Similar methods of treatment had been attempted previous to the war and had been found untrustworthy. Attempts to treat cases of empyema by simple aspiration had resulted in cure in a small number of cases, but the percentage of permanent cures had been so small that the method never gained

great favor. It must be remembered, however, that these cavities were irrigated in only a few instances and that the treatment was essentially equivalent to open drainage through a small and inadequate thoracotomy wound. With the development of antiseptic solutions which could be used for irrigation, the possibilities of this method were greatly increased. The use of the method was revived at Camp Pike and underwent numerous modifications in the hands of the base hospital staff at that place.[7] Before March 15, 1918, all the cases of empyema which occurred at Camp Pike were treated by rib resection and simple tube drainage without irrigation. On account of the great quantities of pus which drained from the wounds, the dressings were constantly saturated with exudate. Tubes of small caliber were inserted through the wound to the bottom of the cavity and the exudate was aspirated frequently. This obviated the necessity of changing the dressings several times during the day. The mortality among these cases was 42.3 per cent.

Dakin's solution was next employed to irrigate the cavities. After April 15, 1918, a radical change was made in the method of drainage. Diederich [7] suggested that the cavities be aspirated and irrigated through a catheter introduced through a stab wound in the chest wall. The operation was still further modified by the use of a trocar and canula to facilitate the introduction of the catheter.[7] The catheter was introduced after a preliminary diagnostic aspiration, and when the pus had been removed Dakin's solution was intermittently injected into the cavity. The frequent instillations of this antiseptic dissolved the fibrin, and since the catheter did not allow the admission of air the pleural surfaces were held in contact and the lung was kept expanded. The method was further developed by Mozingo,[8] who injected 2 per cent formalin in glycerin in the cavities to obtain final sterility before removing the catheter. The mortality in a series of 113 cases treated in this manner was 7 per cent. This mortality is slightly higher than that at Camp Lee in a series of cases which were treated by aspiration and subsequent thoracotomy, so that a comparison of this method with open drainage after preliminary thoracotomy gives no preference to either with respect to mortality.[6] Both of the methods accomplished a similar purpose; that is, to tide the patient over the critical period of the pulmonary infection. Both series of cases covered a period after April 15, 1918, when the virulence of the infection was subsiding.

Accurate data covering a large number of cases treated by the closed method have not been obtained. A number of the cases recurred and others required secondary operations to bring about healing. In a small percentage sterile pus was found after the catheter had been removed for several weeks. A few of these exudates showed streptococci on culture. An analysis of such data as could be obtained has been attempted in Tables 50 and 51. The analysis comprises a comparison of some antiseptics previously mentioned so that the results of the treatment regarding the number of recurrences, the number of secondary operations required, and the final condition of the patient (his symptoms and his ability to work) may be studied.

In so far as the secondary operations, recurrences, and the length of time required for wound closure are concerned, the closed method gives slightly more favorable results; but when dyspnea, pain, and cough are referred to, the open method of drainage appears preferable. In general, a greater per-

centage of the patients treated by open drainage were able to do heavy work than were those treated by the closed method. In either event, where Dakin's solution was used, regardless of the method of treatment, the results have been better with reference to symptoms and work than among those treated by simple drainage without irrigation or by the closed method with formalin. In either case, Dakin's solution gave better results than the other antiseptics. Bismuth paste was the poorest form of antisepsis.

TABLE 50.[a]—*Operations required after various types of treatment and antisepsis.*

Treatment.	Operation. First. Cases.	First. Interval before operation.	Second. Cases.	Second. Percentage.	Second. Interval before operation.	Third. Cases.	Third. Percentage.	Third. Interval before operation.	Fourth. Cases.	Fourth. Percentage.	Fourth. Interval before operation.	Recurrence, percentage.	Final wound closure, average days.
Dakin-full [b]	252	9.2	55	21.8	132	15	6.0	248	6	2.4	361	5.16	86.64
Dakin-part [b]	723	8.4	175	24.2	137	56	7.6	249	19	2.6	318	6.08	97.07
Bismuth [b]	47	8.2	20	41.7	185	10	21.0	365	2	4.2	224	16.71	99.0
Simple drainage [b]	1,043	6.6	190	18.2	126	59	5.6	244	12	11.4	329	7.86	84.55
Simple drainage with suction	69	6.9	15	21.9	151	15	5.6	237	......	......	......	3.3	66.2
Catheter drainage:													
a. Formalin and glycerin	18	......	1	5.5	......	......	......	......	......	......	......	5.5	......
b. Dakin's solution and glycerin	39	......	3	7.6	......	2	5.1	......	......	......	......	5.5	41.5
c. Dakin's solution	72	......	13	18.0	......	5	6.9	......	......	......	......	5.5	66.0

[a] Source of information: Special empyema reports made to the Office of the Surgeon General.
[b] These figures are subject to the same interpretation regarding transfers of cases from simple drainage to treatment with sodium hypochlorite solution as are the figures in the tables for the intervals of wound closure.

TABLE 51.[a]—*Symptoms and ability of patients to work after various types of treatment and antisepsis.*

Treatment.	Dyspnea, percentage.	Pain, percentage.	Cough, percentage.	Cardiac symptoms, percentage.	Heavy work, percentage.	Light work, percentage.	No work, percentage.
Dakin-full [b]	29.4	39.7	9.1	9.1	50.0	40.9	9.1
Dakin-part [b]	27.4	39.2	12.7	6.5	52.6	35.5	11.9
Bismuth [b]	31.3	39.6	12.5	12.5	54.1	16.68	29.15
Simple drainage [b]	49.9	81.0	20.1	22.0	45.0	35.7	8.0
Simple drainage with suction	17.5	34.9	8.9	6.3	50.74	36.92	12.32
No operation	19.4	35.8	8.5	6.7	63.6	35.42	9.9
Catheter drainage:							
a. Formalin and glycerin	64.29	57.14	28.57	7.1	28.57	42.86	28.57
b. Dakin's solution and glycerin	41.38	51.71	20.69	13.79	51.76	41.40	6.90
c. Dakin's solution	29.10	45.80	20.80	12.00	45.00	50.00	5.00

[a] Sources of information: Reports of sick and wounded made to the Office of the Surgeon General and special empyema reports made to the Office of the Surgeon General.
[b] These figures are subject to the same interpretation in regard to transfers of cases from simple drainage to treatment with sodium hypochlorite solution as are the figures in the tables for the intervals of wound closure.

THE PREPARATION AND ACTION OF NEUTRAL SOLUTION OF SODIUM HYPOCHLORITE (DAKIN'S SOLUTION).

Neutral solution of sodium hypochlorite was used so extensively in the treatment of infected wounds throughout the war that it seems proper to introduce a description of the methods used in the preparation of the solution and a brief résumé of the manner in which it acts on bacteria and on living tissue. Three methods were used. The choice of the method depended, of course, on the facilities available at the base hospital where the solution was prepared. The formulæ followed in preparing the solutions have been transcribed as a matter of record.

1. PREPARATION FROM BLEACHING POWDER, WASHING SODA, AND BORIC ACID.

This is the original formula for making the neutral solution of sodium hypochlorite devised by Dakin.[9] The boric acid rendered the solution neutral when it was first prepared and maintained essential neutrality when it was used. This acid, being polybasic, formed a variety of salts which, through shifts in their relative proportions, tended to preserve the equilibrium in reaction.

To make 10 liters of the solution, 400 grams of washing soda (crystals) or 140 grams of dry sodium carbonate were dissolved in that amount of water; 200 grams of bleaching powder (the "Chloride of lime" or chlorinated lime of commerce) containing from 24 to 28 per cent of available chlorine were added. The mixture was shaken thoroughly to promote contact and to render the calcium carbonate, which was at first precipitated as a white cloud, granular, so that it could be removed by filtration. Ultimately, it was a saving of time to devote as much as 10 minutes to this constant agitation of the mixture, so it was most convenient to use a well-corked bottle for making the solution. After shaking, the mixture was allowed to stand for half an hour or longer. When the precipitate had settled the clear supernatant liquid was siphoned off and filtered through paper or a cotton plug inserted in the neck of a funnel. Forty grams of boric acid were dissolved in this clear filtrate, which was then ready for use.

If the bleaching powder contained 25 per cent of available chlorine and all of it entered into the reaction with the sodium carbonate, the resulting solution would contain 0.5 per cent of sodium hypochlorite.

The reaction taking place between calcium hypochlorite and sodium carbonate is expressed by the equation:

$$(1)\quad Ca(OCl)_2 + Na_2CO_3 = CaCO_3 + 2NaOCl.^a$$

But bleaching powder contains not only calcium hypochlorite, but several other constituents. Among these are calcium chloride and calcium hydrate which also react with sodium carbonate:

$$(2)\quad CaCl_2 + Na_2CO_3 = CaCO_3 + 2NaCl.$$

$$(3)\quad Ca(OH)_2 + Na_2CO_3 = CaCO_3 + 2NaOH.$$

The third reaction results in the formation of sodium hydrate. It was chiefly to neutralize this sodium hydrate that the boric acid was added. Inasmuch as the amount of calcium hydrate in bleaching powder varied considerably, it was important to determine whether the amount of boric acid used was actually sufficient to effect neutralization with the particular lot of bleaching powder. This was determined readily by sprinkling a few particles of solid phenolphthalein upon the surface of the solution. If the solution was alkaline, a pink color was developed. In this case more boric acid was added. If the particles did not become pink, an adequate amount of boric acid had been added. An excess of boric acid reduced the keeping qualities of the hypochlorite solution.

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[a] The active or available chlorine in bleaching powder is sometimes assumed to be combined with calcium in conjunction with chlorine in the inactive state. On this assumption the reaction with sodium carbonate is expressed by an equation intermediate between (1) and (2): $Ca\langle {}^{Cl}_{O-Cl} + Na_2CO_3 = CaCO_3 + NaCl + NaOCl.$

2. THE PREPARATION FROM BLEACHING POWDER WITHOUT THE USE OF BORIC ACID.

This formula was proposed by Daufresne.[10] The idea upon which it was based was the use of carbonic acid in place of boric acid to secure neutrality. The requisite amount of carbonic acid was supplied by substituting an appropriate amount of sodium bicarbonate for a part of the sodium carbonate in Dakin's original formula. The proportion of sodium carbonate to sodium bicarbonate required to attain this result depended upon the composition of the bleaching powder, and particularly upon the amount of calcium hydrate it contained.

For the ordinary brands of bleaching powder the following proportions gave good results: Two hundred grams of bleaching powder containing from 24 to 28 per cent available chlorine were dissolved in 5 liters of water. The solution was allowed to stand for an hour. Ninety-four grams of dry sodium carbonate (or 265 grams washing soda in crystals) and 86 grams of sodium bicarbonate were dissolved in 5 liters of cold water in a separate container. These solutions were mixed and thoroughly shaken. When the granular calcium carbonate had settled the supernatant fluid was siphoned off and filtered.

If the solution prepared in this way were alkaline when tested with solid phenolphthalein, it was neutralized with boric acid, or carbon-dioxide gas was passed into the solution until there was no reaction with phenolphthalein. When this neutralization was necessary, the amount of bicarbonate was increased and the carbonate correspondingly reduced until the proportion suiting the particular bleaching powder used was found.

3. THE PREPARATION WITH SODIUM CARBONATE AND CHLORINE GAS.[11]

Chlorine gas was passed into a solution containing 15 grams of dry sodium carbonate (17.6 grams of the monohydrate or 40 grams of washing soda) to the liter, 4.8 grams (about 1,700 c. c.) of the gas were required for each liter of the solution. The reaction which takes place between the sodium carbonate and chlorine may be divided into two stages:

$$(1)\quad 2Na_2CO_3 + 2Cl + H_2O = NaOCl + 2NaHCO_3.$$

$$(2)\quad 2NaHCO_3 + 2Cl = NaOCl + NaCl + 2CO_2 + H_2O.$$

The final products are sodium hypochlorite, sodium chloride, and carbon dioxide.

This method of preparing sodium hypochlorite was expeditious and simple in every respect except for the determination of the amount of chlorine necessary. The chlorine was furnished in liquid form, in steel cylinders. A chlorine meter adapted for use with these cylinders was supplied to the base hospitals. A tube ending in an unglazed porcelain diffuser was used to pass the chlorine into the solution. It was necessary to test the solution with great care to make sure that the requisite amount of chlorine and no excess was retained. There are, of course, sources of error in estimating the weight of chlorine by measuring its volume, because the latter is affected by changes in both pressure

and temperature. If the correct volume was once determined according to the meter and the conditions were kept uniform these errors were eliminated.

The sodium hypochlorite solution prepared in this way lacked the "buffer salts" contained in solutions made according to the original formula. The convenience of the method and the rapidity with which large volumes of the solution could be prepared occasioned its wide use in the military hospitals where from 60 to 80 liters were required each day.

4. TESTING THE STRENGTH OF DAKIN'S SOLUTION.

As a result of experimental and clinical observations it was concluded that the satisfactory action of the solution as a surgical antiseptic depended chiefly upon the concentration of available chlorine and the reaction. The reaction was approximately neutral, and the hypochlorite content was not less than 0.4 per cent and not more than 0.5 per cent. Later experience confirmed these conclusions. If the hypochlorite content of the solution was below 0.4 per cent, its efficiency as a germicide was very greatly reduced; if the concentration was above 0.5 per cent, the solution was unduly irritating. These limits were so narrow that in view of the variations in strength likely to occur in the preparation of the solution because of differences in the composition of the materials used or in the manipulations, it was necessary to determine the strength of the solution when it was first prepared. The liability of deterioration after a few days made these tests necessary if solutions were not used immediately after preparation.

The determination of hypochlorite concentration was made by titrating with a decinormal solution of sodium thiosulphate (24.82 grams of the crystallized salt ($Na_2S_2O_3$ $5H_2O$) dissolved in 1,000 c. c. of distilled water). One cubic centimeter of this thiosulphate solution (N/10) is equivalent to:

0.0127 gram iodine.
0.00354 gram chlorine.
0.00262 gram hypochlorous acid, HOCl.
0.00372 gram sodium hypochlorite, NaOCl.
0.01407 gram chloramine-T, CH_3, C_6H_4, SO_2NaNCl.
0.006 gram dichloramine-T, CH_3, C_6H_4, SO_2NCl_2.

In addition to the standard solution of sodium thiosulphate, the reagents required were a 10 per cent solution of potassium iodide; pure acetic acid, 10 per cent; and starch paste, prepared by boiling about 0.1 gram of starch with 100 c. c. of water.

The titration was made in the following manner: Five c. c. of the iodide and acetic acid solutions were added to 10 c. c. of solution. This mixture at once turned brown on account of the liberation of iodine. The decinormal thiosulphate solution was dropped from a graduated burette until the brown color nearly disappeared. A few drops of the starch paste were added and the titration was continued until the mixture was colorless. The number of cubic centimeters of standard thiosulphate solution, required to complete this reaction, multiplied by the factor 0.00372 (see above) gave the weight of sodium hypochlorite in the 10 c. c. of Dakin's solution taken for the determination. This multiplied by 10 gave the percentage strength.

TESTING THE REACTION OF DAKIN'S SOLUTION.

If the solution was too alkaline it was unduly irritating to the tissues; if too acid it deteriorated rapidly. Solutions were prepared which did redden particles of solid phenolphthalein sprinkled upon the surface. An empirical test for undue acidity consisted in expressing about 0.5 c. c. of one per cent alcoholic solution of phenophthalein from a medicine dropper into about 5 c. c. of the solution to be tested. Solutions of the proper alkalinity showed a momentary flash of red. If there was not at least a momentary flash of red, the alkalinity of the solution was not sufficient to prevent rapid loss in hypochlorite content.

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CHAPTER V.

THE RÔLE OF THE ROENTGEN-RAY LABORATORY IN THE STUDY AND TREATMENT OF EMPYEMA.

The Roentgen-ray laboratory was utilized probably more generally throughout the Army camps than any other laboratory which was designed to assist the clinician and surgeon in diagnosis. In the first place, it furnished evidence of organic lesions which could be preserved as a definite record of the condition at the time the exposures were made, and these records could be compared with those obtained at later stages of the disease; second, it was not time consuming and might be used to confirm diagnoses which could not be made with certainty by physical examination alone; third, it very largely eliminated personal opinion because of the objective character of the evidence it gave. Although the elimination of personal opinion in regard to the clinical aspects of disease is not usually to be desired, it was necessary in many instances on account of the time which might be saved by turning to the roentgenologist for a diagnosis. More evidence was often secured in a brief time than could be gleaned from an extended clinical study. This was true in surgical conditions which were the result of injury when immediate diagnosis was necessary. No delay was warranted. In medical diagnosis, however, more time might be spent in clinical study, and the Roentgen ray was then used as a confirmatory method. In unusual conditions or in cases of doubtful diagnosis it aided the internist immeasurably.

This indebtedness to the radiographer was particularly great in the diagnosis and care of the numerous cases of pleuritis which occurred in America during the mobilization and training of the Army. Similar epidemics had been encountered in previous wars, but the knowledge and experience acquired then were not abreast of the modern methods in medicine, and the records made at these times were correspondingly incomplete on many aspects of the disease. The first clear conception of these fulminating pulmonary infections came from the post-mortem evidence of their pathology. On account of the errors which the clinician was frequently led to make, both because of his inexperience with the disease and the unreliability of the physical signs in many of the cases, it then became customary to follow pneumonia radioscopically from the onset of the infection. The aid rendered in the diagnosis of pneumonia and pleuritis was invaluable, especially because it was not only applicable during the acute stages of the disease but assisted the surgeon after the case had come under his care. Since the great preponderance of disease among the personnel of the Army was respiratory (there was not only the epidemic of measles and streptococcus pneumonia, but in addition a wave of influenza of unparalleled severity), the rôle played by the roentgenologist may easily be imagined.

Previous to the war the roentgenologist had attained a high degree of efficiency in the study of pulmonary tuberculosis. Much of this work was done in conjunction with the clinician, or the physician who was especially

interested in thoracic medicine interpreted his own radiograms. Although it was possible to maintain a sympathetic association such as this in the Army hospitals, circumstances frequently made it impracticable from both the technical and the administrative standpoints. As a result there was a tendency for each department to carry on its allotted function without sufficient correlation with the other branches of the hospital service. When the epidemic of pneumonia swept the cantonments in the eastern part of the United States in 1917 and 1918, the diagnostic value of fluoroscopic examinations and of roentgenograms was quickly realized, and the impetus given the study of acute respiratory diseases was remarkable. The necessity for accurate diagnosis was impressed on every Army physician. The attempt to lessen the mortality by a more thorough knowledge of the disease led to a free interchange of ideas between the roentgenologist and the ward surgeon. As empyema developed and cases came to operation, the surgeon again strengthened this intercourse. Plates were often essential in locating encapsulated pockets of pus. They were necessary in the intelligent treatment of chronic cavities and sinuses when large decortications or constructive surgery were indicated, because there was no other means by which the extent and location of these cavities could be determined so accurately. Hence the surgeon often depended on stereoscopic plates of the injected cavities to assure himself of the necessity for interference or of the extent and character of the operation required. In these ways, on account of the fact that the roentgenologists had facts to offer which could not be supplied by clinical experience and judgment alone, the bond between the ward, the operating room and the X-ray laboratory of a necessity became more firm.

The equipment found to be necessary followed the demand made by these cases. During 1917 and the early months of 1918 the hospitals were equipped with stationary radiographic apparatus. Since there were no portable sets at that time, it was necessary to carry patients to the laboratory. Frequently, even when examinations were much needed, it was undesirable to move those who were critically ill, so bedside units were introduced to obviate this circumstance. These bedside units were perfectly serviceable for the confirmation of the diagnosis of pneumonia or the detection of fluid, and in some respects, particularly because the record was permanent, they were superior to the fluoroscope, which gave no advantageous technical detail and involved moving the patient. In examinations for the localization of encapsulations or for the study of cavities after operation, they were not as valuable as the standard tables and stands, since they did not afford facilities for stereoscopic plates.

The important functions of the Roentgen-ray laboratory during the drainage period were the study of the chronic cavities and the detection of pus pockets. Stereoscopic plates were always more valuable for these purposes. When the wounds were healed there was often some difficulty in excluding the presence of an active tuberculous lesion unless stereoscopic plates were made. These plates showed greater detail, but definite diagnosis was at times impossible. In general there was no great improvement in the type of apparatus employed in thoracic work aside from the development of the portable bedside units and the application of tubes which could be operated successfully at a low amperage.

The methods utilized in the study of pneumonia and empyema were modified to some extent when it was found that there was need for improvement in the technique employed. Previous to the war it had been the custom with many roentgenologists to expose chest plates with a relatively high amperage and to correspondingly shorten the time of exposure. Greater detail was secured in this manner when stereoscopic plates were desired, since it was possible to eliminate some of the respiratory movement by the shortened exposure. After the spring of 1918, however, the maximum milliamperage was limited to 45 by an order from the Surgeon General's Office.[1] This memorandum was issued with the idea that the time during which Coolidge tubes were serviceable could be lengthened when a low amperage was used. This limited amperage did not affect the routine examinations, but if patients were especially dyspneic a milliamperage of 60, with an exposure of one or two seconds, at times resulted in clearer roentgenograms. The methods used in the study of cavities and sinuses were improved in some instances to secure more accurate roentgenograms, but the modifications were slight. The chief developments were in the direction of keener interpretation, the greater utilization of available modes of study, and the dissemination of the acquired experience among the physicians in the Army at the time.

Cases of empyema pass through three stages. These stages are a formative period, which includes the interval between the onset of the effusion and the time at which surgical drainage is instituted; the period of drainage proper, either by an open or closed method; and the period of convalescence after actual healing of the external wound. Although a division which is based on the method of treatment and the therapeutic requirements of the patient might be considered somewhat unsound, since it is not primarily pathological in its inception, it nevertheless affords an actual working basis for a consecutive consideration of the various applications of the Roentgen ray, as the objects and purposes for which it was employed during these periods were distinctly different. With this division in mind, the following text has been written in three parts.

THE FORMATIVE OR PREOPERATIVE STAGE.

RELATION BETWEEN PNEUMONIA AND EMPYEMA, AS SHOWN BY ROENTGEN-RAY STUDIES.

The occurrence of empyema is so intimately associated with pneumonia that it is difficult to consider the two separately with precision. Since one follows the other, such a separation is possible in typical lobar pneumonia and the subsequent empyema, but is difficult in streptococcus infections because the effusions occur in all stages and degrees of lung infection, and can less frequently be considered postpneumonic. When streptococcus infections were common, in 1917 and 1918, it was not an unusual thing to discover a large effusion when there had been no previous clinical evidence of parenchymal lung involvement. To demonstrate an actual pneumonia under these conditions, examinations were necessary before the physical signs were obscured or modified by the presence of fluid. It is noteworthy that it was as frequently impossible to discover consolidation by roentgenograms when the early clinical symptoms pointed to a pleuropulmonary infection. There is no reason to suppose that

FIG. 23.—Roentgenogram illustrating an encapsulated empyema following lobar pneumonia.

in these streptococcus cases there was not an actual involvement of the lung antedating the effusion, but before there was sufficient consolidation, apparent either by percussion or in roentgenograms, the affected half of the chest was so filled with fluid that all lung detail was obscured. It was in cases of this type that the later clinical findings were so confusing as to cause difficulty in distinguishing between massive pleuritis and consolidation. It was always possible to make a decision with the fluoroscope or a single plate.

Later when effusion occurred, after evidence was definitely established pointing to a lobar pneumonia type of consolidation, or to an irregular diffuse bronchopneumonic type of consolidation, the transitional stages in the pneumonic shadows were easily followed. The type of lobar pneumonia most frequently encountered first gave a sharply limited shadow of varying density, which increased with the degree of consolidation and was less and less marked as resolution progressed. When empyema followed the pneumonia, especially if it had been confined to a part of the lung at some distance from the diaphragm, so that the shadow was discrete and distinct, the lung detail was obscured by the more even diffuse shadow of the exudate, which did not clear within the period of seven or eight days normally required for resolution. When the pneumonia was at the base of the lung and the axillary margin was involved, the fluid often obliterated the diaphragmatic angle. More frequently there was only a dense shadow posteriorly over the lower lobe.

The bronchopneumonia which was prevalent was a generalized patchy involvement of several lobes with a tendency to become confluent in various areas. The plates were perfectly distinctive in that they showed the irregular distribution of the consolidation. The effusions which occurred in these cases were either free or encapsulated, but in either case they were of greater density than the areas of consolidation. Wherever fluid accumulated, the lung structure and the patchy appearance of the bronchopneumonia were obscured by the dense homogeneous shadow of the exudate. Ordinarily, plates at intervals of two or three days showed the lungs resuming their normal density, while the shadows of the encapsulations persisted. Resolution was occasionally so slow that small encapsulations were not easily detected on account of the similarity between the appearance of small pus pockets, with considerable parenchymal involvement of the adjacent lung tissue, and the patchy shadow of an early bronchiectasis, with considerable peribronchial infiltration which sometimes supplanted the shadow of the bronchopneumonia.

The shadow of the empyema following lobar pneumonia occurred where the lung had previously shown the greatest involvement. Although it was not always sharply limited in the roentgenograms to that part of the lung surface which had appeared consolidated, the location was approximately that of the pleura which had been involved by the pneumonia. Lobar pneumonia was most frequent in the lower lobes and the shadow of the subsequent empyema was most intense over the lower posterior or lateral pleural surface corresponding to the area of consolidation. This is shown in Figure 23.[a] Under varying conditions there were other areas where the first lung changes incident to the infection were observed. One of the commonest sites during the influ-

[a] The roentgenograms used to illustrate this chapter were obtained from Base Hospital, Camp Lee, Va., General Hospital No. 12, Biltmore, N. C., and Walter Reed General Hospital, Washington, D. C. They were photographed at the Army Medical Museum.

enza epidemic was just lateral to the hilus of the lung.[2] Pneumonia, following influenza, although caused by pneumococci in most instances, was secondary and can not be classed as typically lobar; but when the pneumococcus was found to be the predominating organism in the sputum and the pleural fluid, the shadows of the pneumonia and the empyema usually occupied successively the same area of the pleural surface. There was not always the sharp coincidence found in the lobar type of distribution, but probably this may be explained by the fact that influenzal pneumonia had a bronchopneumonic type of distribution. The pus in all of the pneumococcus cases was apparently so surrounded by adhesions and was produced in such minor quantities that it did not invade the entire pleural cavity, consequently shifting of the fluid shadow could seldom be demonstrated. A consideration of the pathology of the pleuritis complicating pneumococcus pneumonia, which comprises a gradual infiltration of the fibrinous pleural exudate overlaying the pneumonia with leucocytes and pneumococci, accounts for the course followed by these cases.

THE FLUID SHADOW AND THE EFFECTS OF THE ACCUMULATED EXUDATE.

The effusions containing hemolytic streptococci were usually large in amount. This was especially true of those which occurred early in the pneumonia or developed before there was roentgenologic or clinical evidence of consolidation. Since the chest was very quickly filled with fluid, once effusion had begun, opportunity was afforded for a study of the displacement of the mediastinal structures and variations in the aeration of the lung due to the accumulation of exudate before and after drainage. The course of these cases was especially instructive when followed from the beginning of the effusion in conjunction with the roentgenologist.

For the first examination of these cases of fulminating pleurisy either a single plate or the fluoroscope was found satisfactory. The fluoroscope showed disturbed function which could not be demonstrated readily with plates, but on the other hand plates often aided in the localization of small consolidated areas which might be overlooked on the screen. Immediately following the onset of these infections which were at first predominantly pleural, fluoroscopic examination showed a distinct limitation of motion on the affected side before any great amount of fluid had developed. Apparently this limitation of motion was largely voluntary at this stage and resulted from an effort on the part of the patient to lessen the pain. The diaphragm was practically immobile and the chest wall was fixed in a degree of partial expansion. That this was largely a reflex effort was evident from a few observations on patients who developed fluid so slowly that the visceral and parietal pleuræ in the axillary region were at first scarcely separated, and examinations were possible after the pain had partly subsided, yet the chest had not filled with sufficient fluid to hinder the respiratory excursion. As soon as the pain had subsided the spasm was relieved. The fixation of the chest wall with the lung partly expanded was probably due to the greater relief afforded the patient when this position was maintained, since it permitted a greater degree of unilateral fixation of the chest wall than was possible when the lung on that side was either fully

expanded or contracted. The relief afforded was always greatest when the affected lung was slightly expanded. Increase in the effusion, and later consolidation and adhesions, account for the limited respiratory movements which were observed during the pneumonia and after the drainage of the empyema.

When one was fortunate to secure roentgenograms of an early diffuse pleuritis, the fluid shadow was first observed in the lower axilla, but when considerable fluid had developed this shadow was most dense above the dome of the diaphragm. The fact that the fluid causing the lung to be separated from the chest wall as the costophrenic angle was filled was first apparent in the axilla, does not indicate necessarily that the exudate formed a thicker layer there than over any other part of the lung. It does indicate, however, that a small amount of fluid, spread evenly over the axillary and posterolateral surfaces of the lower lobe, is capable of obstructing the ray to a greater extent in this region. This is due to the greater depth of fluid through which the roentgen rays must pass when the chest is viewed in the anteroposterior position. The shadow first filled the costophrenic angle, then as the exudate increased, the axillary region acquired a density nearly equal to that of the rest of the lower chest, while the lung which was compressed into the upper part of the pleural cavity left a clear area near the apex.

Expansion following drainage could not be observed as satisfactorily as the compression of the lung by the fluid. When the exudate was removed through a catheter so that air was not admitted to the cavity, the expanding lung showed the reverse of the picture just described. The pleura by this time was covered by a layer of fibrin which cast a moderate shadow after the cavity had been emptied as completely as was possible. After the exudate was aspirated there was greater penetration of the upper thorax, while shadows due to the pleura at the base and near the drainage site persisted. Frequently these parts of the chest did not clear entirely until long after the drainage wound had healed. The fluoroscope or single plates were useful during the period of aspiration to indicate the frequency with which the exudate should be removed.

The radioscopic study of large exudates offered evidence which confirmed certain established principles in regard to the aeration of the lungs and the displacement of the mediastinal organs. The displacement of the mediastinal structures which occurs with large unencapsulated effusions has been an important diagnostic sign of fluid from the standpoint of physical diagnosis and of the interpretation of plates. There are changes in the aeration of the lungs accompanying this displacement which are apparently a result of the pressure exerted by the fluid within the cavity. It is obvious that with fluid in one of the pleural cavities sufficient to displace the mediastinal tissues there must be a change in the pressure to which the lungs are subjected. With the increasing pressure in one side of the thorax due to an influx of fluid the heart and other structures are pushed toward the opposite side. At first the lung on the side which contains the fluid is found compressed in the upper part of the chest with but slight displacement of the heart and the tracheal shadows. If fluoroscopic examinations are made at this time the opposite lung is found to undergo complete aeration, but after further displacement of the mediastinal shadow

by larger amounts of fluid, the aeration of the healthy lung is impeded by the pressure. According to the work of Graham and Bell,[3] one should suspect that approximately equal pressures would be maintained on the opposite sides. This would account for the diminished aeration of the healthy lung, since the negative pressure which exists in the healthy pleural cavity would be diminished by an influx of fluid on the opposite side. There is a point in this connection which indicates that the mediastinal structures may bear part of the increased pressure of the fluid and so maintain a pressure on the healthy side which more nearly approaches normal. The study of a number of chests with massive unilateral effusions has shown that the displacement is not always proportional to the amount of fluid in the pleural cavity. The lung on the affected side has been forced so firmly into the upper part of the pleural cavity and is so surrounded by fluid that the chest was of nearly uniform density with but little mediastinal displacement, while roentgenograms of similar chests have shown great displacement of the midthoracic organs. The only explanation which might account for this variation is that the mediastinum had different degrees of mobility, so that similar pressures in different individuals caused greater displacement in some than in others. When the pressure was relieved by the removal of fluid without the admission of air into the pleural cavity, the healthy lung acquired its original density. This can be explained either by the relaxation of the lung when the cubic contents of the pleural cavity were increased as the mediastinum returned to its normal position, or by the readjustment of the intrathoracic pressures. The mediastinal shadow, however, did not assume the normal position at once, but returned to the midline gradually. It is possible that the elasticity of the tissues separating the pleural cavities had been temporarily diminished by the tension to which they had been subjected, and furthermore, that sufficient fluid could not be removed by aspiration to reestablish normal pleural pressures immediately.

Three roentgenograms illustrating the effects of a unilateral effusion have been introduced into this chapter. Figures 24 and 25 were made at short intervals before the pleural cavity was drained, and Figure 26 immediately after the fluid had been withdrawn through a snugly fitted catheter. In Figure 24 the left cavity is obscured by the shadow of a massive effusion which is of sufficient density to obscure the rib shadows except at the apex and in the lower axilla. The heart and trachea are found moderately displaced. This displacement is more marked in Figure 25, in which the increasing effusion has still further obscured the shadows of the ribs and forced the mediastinal organs farther into the opposite cavity, resulting in a decreased aeration of the healthy lung. In Figure 26, obtained on the day following drainage, there is increased penetration of both lungs, indicating that on the left side the removal of the fluid has allowed the lung to expand and on the right that the lung is no longer compressed by the displaced mediastinal organs. The shadows show that although the trachea and upper mediastinum have returned to their normal positions the heart is still displaced. These illustrations show the characteristic changes accompanying the fulminating streptococcus effusions mentioned in the preceding paragraphs.

FIG. 21.—Roentgenogram illustrating a large pleural effusion complicating a streptococcus bronchopneumonia.

Fig. 25.—Roentgenogram illustrating the displacement of the mediastinal and heart shadows. This exposure was made two days after the one reproduced in Fig. 24.

Fig. 26.—Roentgenogram showing the effect of catheter drainage (closed method of treatment) on the effusion illustrated in Figs. 24 and 25.

ENCAPSULATIONS AND LUNG ABSCESSES.

Encapsulations of pus were not unusual in streptococcus infections but were often so obscured by large free effusions or by consolidated lung that they were not discovered until after drainage, or after resolution of the pneumonia. They were most frequent where the parietal and visceral pleuræ had been in contact along the anterior lappet of the lung, between the lung and the pericardium, or between the lobes. It was not infrequent to find an encapsulation anterior or lateral to the apex where the lung had been floated against the chest wall by a large exudate. These encapsulations occasionally occurred behind the hilus near the vertebræ, where they were not easily detected because of the difficulty in distinguishing the shadow from that of the root of the lung.

The pus pockets which were formed during the acute inflammation of the pleura and the accumulation of a large exudate were usually anterior, between the lobes, or paravertebral. These locations were the regions in which the visceral and parietal pleuræ were held together by the buoyant effects of the fluid and in which encapsulation occurred when part of the free exudate was surrounded by adhesions. In many instances when empyema occurred after the bronchopneumonic process was well developed, the effusions were small and were not free in the pleural cavity; they resembled the empyema occurring after lobar pneumonia, in so far as they were limited to the surface of lung areas which had shown the greatest consolidation. Due to the irregular distribution of the areas of consolidation these encapsulations were often multiple.

Exudates limited to the interlobar cleft originated either in a pleuritis which developed soon after the onset of the infection or were subsequent to pneumonia involving the adjacent parts of the lung. On account of the oblique position of the interlobar fissure the appearance of these infections varied in roentgenograms taken in the anteroposterior position according to the type and extent of the inflammation. The localized pleuritis appeared either as a narrow line extending outward from the hilus toward the periphery, or as a cone-shaped shadow with its base situated at the margin of the lung.

The narrow shadows occurred with greatest frequency among the cases which did not require subsequent operation, so that it was assumed they represented a localized fibrinous pleuritis involving but a small part of the pleura between the lobes. The wider shadows were more often associated with purulent exudates which necessitated drainage. From the post-mortem pathology it is probable that in many instances abscesses were an intermediary factor between the pneumonia and the infection of the interlobar pleura, but it was impossible to demonstrate them by roentgenograms. Very often after an interlobar pleuritis had resolved without surgical interference the shadow of the thickened pleura persisted as long as the case could be followed.

Pockets of pus between the pericardium and lung or between the lung and vertebræ were difficult to diagnose when the pus was spread over the pericardial shadow. Further consideration of these cases, however, shows that the heart shadow was not increased in all directions except by a pericardial effusion or an acute cardial dilatation. It is true that some of the encapsulations between the left lung and the pericardium were so large that the right heart border was occasionally displaced, but in these cases the outline along the left border

FIG. 27.—Roentgenogram of an empyema of the interlobar cleft, with an adjacent resolving pneumonia.

Fig. 28.—Encapsulated empyema at the right apex.

45267°—24——15

of the encapsulation did not have the convexity which we have learned to associate with pericardial effusion. Accumulations of pus along the right of the heart caused but little displacement of the apex to the left and presented a straighter line than the rounded curved right border of a distended pericardium. In rare cases pericardial effusions were so pocketed that the pericardium appeared irregularly distended. Then they could not be differentiated from paracardial encapsulations. It was always possible, of course, to aspirate, but on account of the danger of infecting an otherwise healthy pericardium some surgeons considered that the Roentgen ray afforded the only safe method for diagnosis and preferred to explore rather than attempt a diagnostic aspiration.

Pockets posterior to the root of the lung were usually detected after the acute pneumonic process had subsided. The area in which they occurred rendered detection difficult on account of the conflicting shadows of the vertebræ, heart, and bronchi. Even when plates were made in the oblique position the spinal gutter was often obscured by the bodies of the vertebræ. After the pus had been encapsulated for several days the adjacent parts of the posterior lobe reacted to the absorption of the exudate, the septa became thickened and the bronchi prominent, so that the picture was similar in many respects to that of a localized purulent bronchitis. The actual shadow of the encapsulated fluid was not often seen. If there was a large amount of pus it cast a dense paravertebral shadow with a straight lateral border, but in many instances the reaction in the lung was the only evidence of the smaller encapsulations.

Abscesses occurred frequently, and serial plates afforded some opportunity to observe the changes which took place in the lung as they developed. In the majority of instances in which a single abscess large enough to be detected occurred early, the infected area was the site of a slowly resolving pneumonia. Resolution had not progressed far, however, before it was apparent that the lung became mottled and striated. Rarely the pus was discharged into the air passages and the cavity which it had previously occupied could be seen in plates; more often, especially when hemolytic streptococci were responsible for small abscesses, the lung surrounding the infected areas became striated, but the nidus of the inflammation could not be detected. The striæ were more prominent in plates at later intervals and appeared as reasonably dense lines radiating from the point of infection.

When the pleura was involved in the inflammatory process around an abscess it cast a hazy shadow which became heavier as the reaction to the inflammation increased. It was not possible to obtain serial plates of abscesses with a fluid line to illustrate their formation. At times small pleural pockets showing both air and fluid were observed just after the pus had been partially evacuated into a bronchus, but these did not resemble the large cavities, measuring several centimeters in diameter, which occurred in the peripheral part of the lung and which were accompanied by considerable destruction of lung substance. They may have been formed by the rupture of a large peripheral lung abscess into the air passages, or they may have followed a pleuropulmonary fistula communicating with an encapsulated empyema. Relatively little acute reaction existed in the lung tissue adjacent to these large abscesses, and since the

FIG. 29.—Abscess of the apex of the right upper lobe.

walls cast a dense shadow we may assume they were of long standing when they were first observed; in fact, they were seldom seen until several weeks after the pneumonia. On account of the frequency of pyopneumothorax in the early cases and the high percentage of pleuropulmonary fistulæ occurring after drainage of streptococcus effusions, it is probable that many of these large abscesses were of pleural origin and began as encapsulated empyemata. It was not possible to determine from stereoscopic plates whether the pleuræ formed the abscess walls or the abscesses lay entirely within the lung. Usually they appeared to be situated immediately beneath the chest wall without intervening lung tissue. A point of value to the surgeon was the fact that the fluid line shifted with the changed position of the patient. It was possible, by making stereoscopic exposures in various positions of the patient, to discover the lower limits of the cavity which appeared distinctly against the dense tissue of the wall when the fluid was allowed to gravitate away from the lower parts and was displaced by air. This procedure enabled the surgeon to determine the point of election for drainage in the cases in which the lowermost parts of the wall were so thick that it was difficult to determine the lowest point at which an incision would accomplish complete drainage. In cavities in which the fluid was found to shift slowly or only partially, considerable desiccation of the contents was found at operation.

Abscesses of the glands at the hilus were occasionally anticipated on account of the inflammatory reaction in the surrounding lung. Although it was not possible to make a positive diagnosis, because the bronchi overshadowed this area, the radial thickening of the septa about these abscesses could be depended on with a fair degree of certainty. Diagnoses which were made on these findings were confirmed in numerous instances by subsequent operation.

After the resolution of the pneumonia one of the most interesting and practical phases of Roentgen-ray study was terminated. In cases of typical lobar pneumonia the opinion of the roentgenologist was not required as frequently as in bronchopneumonia, which terminated by lysis and in which there was usually some doubt about the condition of the lung and pleura. In some camp base hospitals it was considered advisable to examine all respiratory cases before discharge on account of the insidious nature of these infections. Although this was not necessary in most instances, the pathology which was frequently discovered more than justified the effort.

THE STUDY OF CHRONIC CAVITIES AND SINUSES.

After thoracotomy the surgeon was concerned chiefly with the contraction of the sinus walls, with the shape of the cavity during the acute and chronic stages, and with the thoroughness of the irrigation and drainage. This knowledge was essential for the proper and intelligent care of the patient. The cases which were treated throughout their course by the canula and catheter method of drainage did not, of course, require such frequent roentgenologic examinations, since the visceral and parietal pleuræ were held in approximation as long as the catheter fitted tightly and air was excluded. When drainage was continuous, as in cases where constant moderate suction was applied to the pleural cavity, the only object in obtaining roentgenograms was to exclude the possibility of abscesses or multiple pleural pus pockets. Many of the empyemata treated in this manner did not resolve, unfortunately, so it became necessary

FIG. 30.—An encapsulated pleural abscess with fluid line.

at some later time to resect part of a rib to secure conditions which would permit a permanent closure of the wound. Undoubtedly this treatment was distinctly advantageous even though it did not permanently heal the empyema, because examinations of these cavities after resection showed that they were uniformly smaller than those resulting from any other method of drainage which was attempted in large effusions. In other respects they resembled cavities occurring after immediate surgical drainage or after a series of "medical" aspirations.

Two methods of study were available. In early cases or in those in which there was a very large cavity it was always possible to distinguish the areas of pneumothorax in roentgenograms made in the anteroposterior position. Later, when the cavities were chronic and had contracted so that the axillary part of the chest was filled by the expanded lung, the outline of the lung surface could not be seen, so it was necessary to fill the cavities with bismuth suspension before an accurate idea of their shape and size could be obtained. It was equally important to obtain stereoscopic plates of these injected cavities, a point emphasized by Beck, who found these methods helpful in the study of empyema and in the localization of foreign bodies in cases of purulent pleural effusion after injury.

In addition to the method of treatment employed, the nature of the infecting organism caused considerable variation in the size and location of these draining cavities, not through activity in the pleura, but rather by reason of the type of pneumonia with which the particular organism was most frequently associated. As mentioned in previous paragraphs, the pneumococcus did not produce large, free effusions even when the consolidation had a lobular type of distribution, but rather a circumscribed collection of pus in the exudate overlaying the inflamed lung. Roentgenograms of the thorax, following operations on such empyemata, showed that the cavities were smaller than the majority of those occurring after streptococcus pneumonia and that they were most frequent in the region below the scapula or in the lower axilla. They were also much less chronic and showed less thickening of the pleura. The streptococcus cases, however, presented a variety of pictures. Some of them resulted in small cavities which, except for their chronicity and the remarkable thickening of the pleural layers so characteristic of streptococcus pleuritis, resembled empyemata following pneumococcus infections. There was a greater tendency for them to occur over the anterior parts of the chest, due probably to the lobular distribution of the pneumonia. Then there were large cavities occurring after massive exudates which extended from the angles of the ribs to the midclavicular line. Since it was possible to aspirate these large exudates for several days and allow the pleuræ to become adherent, they were modified by treatment more than any other type; and because they were most often drained through a posterolateral incision, the sinus which resulted from the expansion of the lung and the contraction of the walls extended upward from the wound below the angle of the scapula toward the apex of the lung. The roentgenograms of these cases were the source of considerable information regarding the factors entering into the obliteration of the cavity and the causes of encapsulation and imperfect drainage.

FIG. 31.—Roentgenogram of a chronic empyema cavity. There are adhesions to the diaphragm below.

THE EXPANSION OF THE LUNG AND THE OBLITERATION OF THE CAVITY.

A study of roentgenograms made subsequent to the operation has led to the conclusion that the obliteration of the cavity can be accounted for by three processes which, although they are interdependent, are not equally effective in bringing about cohesion of the pleura in different stages of healing. The expansion of the lung is probably the most important single factor, and according to the roentgenograms could be brought about by aspiration or catheter drainage up to the time of operation. After operation the lung was held more fully expanded through the application of various types of drainage valves which were designed to augment the negative pressure in the cavity and bring the pleuræ in closer contact through increased aeration of the diseased lung. The second factor, the formation of adhesions, appears to be directly dependent on the ability of the lung to expand and fill the thorax, so that the margins of the cavity can be obliterated gradually where the lung is in contact with the chest wall. The third and last mechanical process is the contraction of the cicatricial tissue composing the sinus wall. This has been found to be the only factor which enters into the closure of chronic empyemata in which the lung has apparently reached the possible limits of expansion under the abnormal pleural conditions which exist and in which the pleura is so thick and sluggish that adhesions are no longer produced.

In 1918 Homans [4] reported a series of cases in which he attempted to correlate the data furnished by roentgenograms of pleural empyemata and various clinical observations regarding the time required for the expansion of the lung and closure of the wound. He concluded that the conformation of the surface of the part of the lung which formed the inner wall of the cavity was an important index to prognosis, since the period of convalescence was shorter when this surface was concave than when it was already rounded out to fill the cavity. He reasoned that with a concave surface there was more often sufficient lung tissue between the points at which the lung was adherent to the chest wall to fill the cavity when the lung was expanded than in those instances when the lung presented a convex surface outward and was apparently expanding but was under tension on account of adhesions. While this tenet appears to be true in the early cases, there are some points which must be considered before the principle can be applied to the chronic cases as well.

The surface of the lung in the cases observed immediately after thoracotomy is usually concave, especially when the margin of the lung is adherent to the diaphragm near the costophrenic angle and the apex is held in its normal location. It has not been infrequent, however, to find the margin bound firmly to the upper surface of the diaphragm at a point some distance from its costal origin. In these cases the surface is often convex because the lower parts of the lung are held away from the chest wall, so that the lung is partly compressed and its costal surface must eventually be called upon to cover a greater area if the lung expands to fill the cavity than it would under normal conditions. The second type of convex surface is illustrated in Figure 32. It occurs where the under surface of the lower lobe is partly adherent to the diaphragm but the margin projects freely into the cavity. It has been found that cases of the first type mentioned, in which the surface is concave and is not hampered by adhesions, heal more quickly than do those of the convex type.

FIG. 32.—A chronic cavity with adhesions over the surface of the lower lobe preventing lung expansion.

Fluoroscopic examinations of healing cases have further demonstrated that not all concave lung surfaces are capable of expansion sufficient to fill the cavities. This has been found true especially in chronic empyema when the visceral pleura has been converted into dense contracted cicatricial tissue which is capable of holding the lung away from the chest wall. Cavities of this type are similar to the healed empyema with a pneumothorax. While they have been found to resemble those earlier cavities which have offered the best prognosis on cursory examination, fluoroscopy has shown that the lung is often incapable of expansion and is under such tension that it does not expand on forced expiration or even when expiration is impeded by closing the mouth and nares. It appears, then, that fluoroscopic examination is of more value in determining the actual expansibility of the lung than the study of anteroposterior roentgenograms.

The fluoroscopic examination of many of these healing cases demonstrated the fact that, ordinarily, the lung surface was much more convex in the anteroposterior direction than along a line from the apex to the adherent margin; furthermore, it was found that healing proceeded more rapidly in this direction so that the chronic cavity or sinus finally assumed an elongated shape due to the gradual obliteration of the anterior and posterior margins by adhesions. A study of these margins showed that they were formed by the convex lung surface and costal pleura which converged in almost parallel planes, so that an acute angle was formed at the point of contact. This condition was evidently the most favorable for the formation of adhesions since the lung and parietal pleuræ were brought into contact in these areas and became adherent. The ability of the lung to expand was, of course, always the primary consideration because the production of these adhesions along the margins of the cavity was hindered if the lung surface was under tension and was not closely approximated to the chest wall. While the study of the lung surface was most important early after operation, the condition of the margins was valuable in the more chronic stages. It was apparent that the actual concavity or convexity of the surface was of prognostic value only insofar as it might indicate the ability of the lung to expand and fill the cavity, and that adhesions were formed much more rapidly when this surface was partially rounded and expanded so as to bring the pleuræ in contact more closely at the margins.

The transition between the stage when the cavity is being obliterated rapidly and the period in which the cicatrix gradually contracts to form the chronic sinus is illustrated in Figures 31 and 33. These roentgenograms were made at an interval of three months. In the earlier illustration the margin of the lung is adherent to the surface of the diaphragm while the apex is held in the upper part of the pleural cavity. The lung surface is convex on account of these basal adhesions and from the density of the shadow which it casts is probably covered by a dense layer of cicatricial tissue. The angle at the upper margin is acute, since it is formed by the lung and costal surfaces converging in nearly parallel planes. In the later illustration, Figure 33, the cavity has diminished in size. The obliteration has taken place at this upper margin and along the costodiaphragmatic angle, but there has been no further adhesion between the lung and diaphragm. The roentgenograms not only exemplify the steps in the healing of a cavity of this type, but illustrate the changes which

Fig. 33.—Roentgenogram of the cavity illustrated in Fig. 31 after an interval of two months. The cavity has been reduced in size, but the cicatrix over the surface of the lung prevents full expansion.

take place in conformation of the cavity as it becomes more chronic. The upper margin is less acute, the surface is concave, and there is a dense cicatricial shadow over the lung and the parietal wall. In the still more chronic stages, the scar tissue is so dense that adhesions are no longer formed and the margins are rounded so that approximation of the surfaces is no longer possible. Such cavities contract slowly and usually necessitate thoracoplasty.

The other factors which have been observed to enter into the closure of the empyema cavity are concerned with changes in the conformation of the pleural cavity. There are usually a slight scoliosis, an approximation of the ribs on the affected side and an elevation of the diaphragm, all of which tend to lessen the volume of the diseased pleural cavity so that it is never necessary for the lung to attain its former capacity.

BISMUTH SUSPENSIONS IN THE STUDY OF CAVITIES.

Observation of the early cavities was continued until the entire anterior surface of the lung was adherent to the chest wall. When this stage was reached it was impossible to study the cavities unless they were filled with material opaque to the Roentgen ray, because they were usually posterior and were obscured by the expanded lung. Methods which had been used previously in the study of cavities were found unsatisfactory. Roentgenograms which were made when probes, drainage tubes, or Carrel-Dakin tubes were placed in the cavities did not permit a study of the actual shape and depth. Attempts were made to obtain roentgenograms with bromide, iodide or thorium solutions, but the plates were unsatisfactory and severe local and general reactions sometimes occurred. Roentgenologists who were using a mixture of bismuth and petrolatum, prepared according to a formula devised by Beck,[5] were able to obtain excellent pictures of small cavities, but if the cavity was large and irregular in shape it was often impossible to fill it completely so that small ramifications could be studied. Because it was so difficult to fill the cavities perfectly, the surgeon was occasionally led astray in his estimation of the size of cavities, injected for radiograms just prior to operation. The method was modified by substituting cottonseed oil for petrolatum as a vehicle for the bismuth subnitrate. The cavities were filled by allowing this bismuth-oil mixture to run into the sinus so slowly that the air was displaced from the deepest recesses, then the opening was packed tightly with a gauze strip which had been dipped in a warmed mixture of petrolatum, wax, and bismuth. Stereoscopic exposures were made with the cavity filled and immediately after it had been allowed to empty. After the exposures it was considered advisable to irrigate the cavity with Dakin's solution to remove all traces of bismuth.

The advantages of this procedure over the use of pastes in the study of empyema cavities were mainly due to the liquid character of the vehicle. It was easily removed in cases in which there was perfect drainage and could always be flushed out except where there were sacculations which required secondary operations before the sinus would heal. These instances were rare and where retention of bismuth did occur on account of some irregularity of the sinus wall, the operation revealed pus retention as well. For this reason it was especially valuable in chronic cases for it served as an index to the

FIG. 34.—A chronic cavity with a single large drainage tube.

completeness with which the cavity was being drained and irrigated. It was never retained in any instance in which an operation was not necessary for the proper treatment of the case.

Stewart[6] studied a series of cases in which he employed all of the methods which have been mentioned. He concluded that it was inadvisable to undertake the injection of large cavities for roentgenographic purposes, but found that small sinuses could be studied profitably after they had been filled with a bismuth paste. In shallow cavities a paste is certainly more easily handled because liquid suspensions are retained with difficulty unless the cavity holds a considerable amount of the mixture. It does not seem, however, that there is any valid objection to filling large cavities with oil suspensions of bismuth subnitrate since several hundred cases were profitably studied in this manner at Walter Reed General Hospital and at General Hospital No. 12.[7] Stewart reported one case of poisoning following roentgenography. This is the only case discoverable. From a consideration of the roentgenological studies made with oil and bismuth suspension it appears that the percentage of poisoning has been lower in patients in whom oil was used as a vehicle than among those in whom pastes were introduced into the cavity.

CONFORMATION OF THE CHRONIC CAVITY AND THE RELATION TO DRAINAGE AND HEALING.

Bismuth studies have shown such variations in the size and shape of the cavities, which followed the empyemata occurring in 1918 and 1919, that it has been difficult to draw any general conclusions in regard to the prognosis of these cases from such data alone. It was obvious, both clinically and from observations made in the laboratory, that, although large cavities would heal under irrigation if they were not chronic, when they reached a chronic stage they often required a collapse of the chest wall or a decortication to effect permanent healing. Aside from this fact, the study of the peculiarities of the individual case was the only criterion upon which judgment might be based, because roentgenology permitted the study of one of the factors only, the conformation of the cavity, which entered into the proper condition for the healing of the wound. The second factor, the bacterial flora and the degree of sterility which might be obtained, depended usually on pathology which could not be discovered in roentgenograms. In some instances bismuth studies of the cavities showed mechanical obstructions to drainage, which would account for the chronicity of the discharge and the difficulty experienced in sterilization.

A large percentage of the chronic cavities resulted from the drainage of massive streptococcus pleurisies. The cavities following the open drainage of pneumococcus empyemata were never as chronic and, because the pus was less in amount and sharply encapsulated, they were usually smaller and more varied regarding the location of the thoracotomy wound. However, it has been pointed out that pneumococcus empyema was most frequently posterior over the lower lobes, and, as a result, the majority of the thoracotomies were in this region. With the larger streptococcus effusions, more latitude was possible in the selection of the drainage site because the exudate could be drained if the incision were made at any point between the anterior axillary line and the inner border of the scapula, as the entire posterior half of the pleural cavity

FIG. 35. The cavity illustrated in Fig. 34 after it had been filled with a suspension of bismuth in oil. The cavity communicated with the bronchi through small pleuropulmonary fistula.

was usually filled with fluid. Regardless of the location of the wound, whether it was anterior or well posterior, the greater part of the chronic cavity was always in the posterior part of the thorax. In those instances in which anterior drainage had been done, the main part of the cavity was in the scapular region and extended forward to the wound through a narrow sinus.

The majority of these cavities finally assumed an elongated shape in the region of the posterior axillary line. Bismuth injections have shown such a variety of shapes that it is hardly possible to attempt a useful classification on this basis. Sixty per cent extended from the thoracotomy wound toward the apex of the lung along a longitudinal axis which deviated slightly toward the spine in the upper part of the thorax. The distance between the lung and the chest wall was usually 1 and 2 cm., but the anteroposterior diameter was variable, because some of the cavities had contracted until they were mere sinuses while others reached from the midaxillary line to the inner border of the scapula. Ten per cent were similar in every respect to those just mentioned except that they reached below the thoracotomy wound, as shown in Figure 37. An additional 10 per cent reached even to the diaphragm, so that the base was broad and the lung was held away from the chest wall by adhesions to the diaphragm, as illustrated in Figure 32. The remainder were irregularly shaped, varying from sinuses extending between the lobes of the lung to large lobulated cavities overlying a large part of the lung surface.

When the cavities were of many months' standing, bismuth studies were valuable only in so far as they might indicate the extent of any surgical procedure which might be undertaken; but in the earlier stages, when marginal adhesions were being formed and the cavity was diminishing rapidly in size, the shape of the cavity often indicated the probable outcome of the case. The majority of the cases, which were easily sterilized and closed permanently within a few months after the operation, were of the posterior, elongated type which resulted from low, posterior drainage. It was never possible to determine definitely which cavities would heal and which would become chronic sinuses, but the prognosis was always better in the posterior elongated type because of the greater ease with which they could be sterilized. The high percentage of chronic, refractory cavities and sinuses, which fall in this class, is due to the great number of early cavities which assumed this shape before they healed. The favorable results in the early cases can be accounted for by the regularity of the walls and the mechanical perfection of drainage which allowed better irrigation than was possible when adhesions had prevented the proper expansion of the lung and had caused the cavity to be irregular or to drain poorly.

In a previous paragraph it was noted that about 60 per cent of the chronic sinuses were posterior and extended upward from the wound toward a point just posterior to the apex of the lung, and that a large majority of the cavities which healed early had assumed this position before healing. A study of cases during various stages of healing indicated that there were several factors which might cause the cavity to assume this position. The first factor was the location of the empyemata. This was over the posterior and lateral aspects of the lower lobe. This common location of the empyemata did not account for the position of the sinus following generalized, streptococcus

FIG. 36.—A chronic sinus over the posterior surface of the lung. Bismuth-oil injection.

FIG. 37.—A chronic sinus over the posterior surface of the lung. Bismuth-oil injection.

FIG. 38.—The result of a thoracoplastic operation on the cavity illustrated in Fig. 37.

FIG. 39.—The cavity illustrated in Fig. 32 filled with a suspension of bismuth in oil.

FIG. 40.—The result of a thoracoplastic operation on the cavity illustrated in Figs. 32 and 39.

FIG. 41.—A shallow cavity over the posterior surface of the lung. Bismuth-oil injection.

FIG. 42.—The result of a thoracoplastic operation on the cavity illustrated in Fig. 41.

pleuritis, except that the greatest accumulation of fluid was in the lower posterior thorax in these cases. The selection of this site for thoracotomy tended toward the localization of the sinus in this area, but did not explain the fact that after drainage in the anterior axillary line the anterior part of the cavity healed rapidly while the posterior part persisted to form the chronic sinus. This could be explained in the first place by the accumulation of exudate in this region which resulted in thicker, cicatricial layers, and in the second place, by the tendency of the lung to adhere more quickly to the chest wall over its anterior surface.

The remaining 40 per cent of the chronic cavities showed either adhesions which prevented expansion, or such irregularities in shape that there was continual pus retention. This retention of pus was always associated with difficulty in sterilization and was often due to mechanical factors which were the result of adhesions and the contraction of the cicatrix during the obliteration of the cavity. Since the bismuth mixture used was of a consistence similar to the discharge from the cavities, it was possible to determine the causes of retention and poor drainage from the roentgenograms made immediately after the mass was drained out, because it collected in various parts of the cavity in considerable amounts when drainage was obstructed. Three main causes of pus retention were discovered in this manner. These were a poorly chosen operative site, a contraction of a cicatrized sinus which was long and sinuous and opened into a large cavity, and lobulation of the cavity by contraction of the scar tissue until areas were practically separated from the rest of the cavity and tended to form encapsulated pleural abscesses. In practically all of these instances in which bismuth was retained it was easily removed by flushing even though there was some obstruction to its free egress. In rare instances where part of the cavity had been separated by the pleural cicatrix it was removed with greater difficulty; a secondary thoracotomy was occasionally necessary before the partially encapsulated pus pockets could be emptied of the retained bismuth and purulent exudate.

Imperfect drainage due to the site of the operation occurred when resection had been done in the anterior axillary line or high in the posterior axillary line for the drainage of a large free exudate filling the posterior part of the pleural cavity. In these instances the bismuth collected in the cul-de-sac below the level of the drainage wound as shown in Figure 37. Flushing was sufficient to remove the bismuth; but on account of the improved drainage it afforded, a properly placed thoracotomy opening hastened healing. Occasionally these cavities would heal readily without secondary operations if they were relatively recent and if thorough dakinization was carried out. The obliteration of the cul-de-sac was brought about by costodiaphragmatic adhesions. The second type of pus retention occurred where there was no irregularity in the shape of the cavity but the sinus had been allowed to contract before the discharge had ceased. These cases, a type of which is illustrated in Figure 43, responded to dilatation of the sinus. The third type of retention due to adhesions within the cavity will be mentioned in the succeeding paragraphs. It is sufficient to state here that it was rare in pneumococcus empyemata or in thoroughly irrigated cavities. While it was possible to ensure spontaneous healing in these cases if the faulty drainage was corrected early, when the cavity was very chronic and refractory this seldom resulted in much change in size, though it was possible to sterilize a certain number by intense irrigation.

FIG. 43.—A cavity with a narrow, contracted sinus. On account of the narrow opening the bismuth and oil could not be removed without the insertion of a catheter. This exposure was made before the cavity had been irrigated to remove the retained suspension of bismuth.

FIG. 44.—The cavity illustrated in Fig. 43 after dilatation of the sinus and irrigation with sodium hypochlorite. This exposure, made after an interval of three months, demonstrates the obliteration of the main part of the cavity under this treatment.

FIG. 45.—An irregularly shaped chronic cavity filled with a suspension of bismuth in oil.

FIG. 46.—The cavity illustrated in Fig. 45, after an interval of one month. The cavity had been irrigated with sodium hypochlorite solution during this time. There was an obliteration of the cavity in all its diameters.

When the drainage and irrigation were improved, cavities which had become practically stationary usually diminished in size. This was noted especially in the very narrow sinuses which extended several centimeters through dense parietal cicatrix and then opened into a bulbous cavity higher in the thorax. The walls of the cavity were either rounded or irregular and shallow. When the sinus was dilated and Carrel-Dakin treatment assiduously carried out, roentgenograms of the injected cavities showed that there was considerable decrease in size after an interval of a few weeks. Small irregular lobulated parts of the cavity were the first to be obliterated by adhesions. In general, the prognosis in so far as the obliteration of the cavity was concerned, was best in cases which were not exceedingly chronic and in which the anterior and posterior margins were thin and slightly irregular. Margins of this character could be studied in stereoscopic roentgenograms of the bismuth-filled cavities. They usually indicated that the visceral and parietal pleuræ were still closely in contact in those areas and that adhesion was still occurring. When the walls had become thoroughly cicatrized these margins appeared rounded or obtuse on account of the gradual contraction of the scar tissue which exerted tension on the lung and tended to separate the lung surface and chest wall along the edges of the cavity. When these margins were so modified the majority of the cavities were practically stationary and there was but slight change in size even after long intervals.

In spite of careful examinations during the drainage period a certain number of encapsulated pus pockets were found late in convalescence. The majority proved to be abscesses within the parenchyma of the lung or pleural pockets some distance from the draining tract. These abscesses were probably formed during the acute inflammation of the pleura, and had been overlooked in the early roentgenograms because they were obscured by the thickened pleura and by the reaction in the lung tissue adjacent to the cavity. Abscesses and encapsulations did occur, however, in cases where the previous examinations left no doubt concerning the absence of pathology aside from the draining cavity. Many of these encapsulations were near the draining tract and in parts of the chest which had been previously occupied by cavity, so their origin could be explained only by assuming that they had been formed through the sequestration of a part of the tract by adhesions or by the contraction of cicatricial tissue. Occasionally, cases were found in which series of roentgenograms at frequent intervals demonstrated that irregular and lobulated cavities were at times divided in this way so that the sequestration of pus actually occurred. When the sequestra were small, thorough irrigation before the connecting sinus had completely closed was usually sufficient to cause sterilization and healing of the pocket. Large sequestra required secondary thoracotomy. Roentgenograms of massive effusions have shown the lung floated against the upper anterior chest wall by the accumulation of exudate in the lower posterior part of the pleural cavity. Autopsies on cases which died within the first few days of the infection indicate that adhesions are first formed over the anterior surface of the upper lobe where the lung and the parietal pleuræ are in contact; when the exudate has been partly removed or has not been sufficiently large to compress the lung into the apex of the pleural cavity, the adhesions have occurred over correspondingly greater areas of lung surface and along the rounded spinal margin. Especially have adhesions been found along the line formed by the upper border of the exudate. With the gradual withdrawal or absorption of fluid,

FIG. 47.—A chronic cavity with lobulation. Bismuth-oil injection.

FIG. 48.—The cavity illustrated in Fig. 47, immediately after the bismuth mass had been allowed to escape. There was retention in the lobulation. This showed imperfect drainage.

adhesions have occurred along this receding line where the lung and chest wall come into contact. As the fluid always accumulated in greater amounts over posterior and lateral surfaces of the lower lobe, these surfaces were the last to become adherent. After thoracotomy the cavity naturally corresponded to the part of the thorax from which the residual fluid was removed at operation.

The majority of the cases appear to have been drained surgically while there was still considerable exudate in the pleural cavity, so the parietal pneumothorax produced by the collapse of the part of the lung which was not yet adherent prevented further contact of the pleuræ in this region. By filling these cavities with bismuth suspension the directions along which adhesions were formed could be determined by the rapidity with which the cavity diminished in size in a series of roentgenograms. Certain parts of the lung surface were usually adherent when the first roentgenograms were obtained following the operation. The lung between the angles of the ribs and the vertebræ, as well as the apex and that portion of the anterior surface near the mediastinum, were found to be bound to the chest wall in a large majority of these early cases. It appears that adhesions were then formed most rapidly along the circumference of the lung surfaces which were most convex and which were capable of the greatest expansion, because the anteroposterior dimension of the cavity diminished more rapidly than obliteration took place from the apex of the lung in the direction toward the thoracotomy wound. As a result of this difference in the rapidity with which adhesions were formed in these two directions, the chronic sinus assumed the elongated shape previously mentioned. Adhesions were formed much more slowly along the posterior than along the anterior margin, so the anterior and axillary lung surfaces were soon adherent, leaving a posteriorly located cavity or sinus.

The direction of the chronic sinus has been referred to frequently in the preceding paragraphs. It was noted, in every instance where the lung had expanded and had not been impeded along the lower margin by adhesions to the diaphragm which held the surface away from the parietal wall, that these sinuses were directed posteriorly rather than anteriorly from the thoracotomy wound. This was accounted for by the position of the angles of the ribs and the increase in the circumference of the lung at successively lower levels from the apex to the diaphragm. Adhesions were formed early over the posterior surface as far as the costal angles, so there was a tendency for the lower part of the posterior margin of the cavity to be situated more anteriorly than portions of this margin which were nearer the apex. Furthermore, since the apex was adherent early, the upper, anterior parts of the cavity were obliterated by advance of the adhesions around the lesser apical circumference, while the anteroinferior parts were not closed by adhesions so quickly because of the greater extent of the pleural surface over this greater lung circumference. The combination of these two factors, together with the sluggish formation of adhesions from the apex directly toward the thoracotomy wound, accounts for the oblique direction over the posterior surface of the lung and the elongated shape of the sinuses.

PLEUROPULMONARY FISTULA.

Pleuropulmonary fistula was a common cause of delayed healing. These fistulae occurred with the greatest frequency in cases of chronic streptococcus empyema, and because the fistulæ were continual sources of contamination, cavities so complicated were difficult to sterilize. Fistulæ were usually

FIG. 49.—A shallow posterior empyema cavity filled with bismuth suspension.

Fig. 50.—The cavity illustrated in Fig. 49 after the bismuth suspension had drained out, but before irrigation.

suspected because of the severe cough and the expectoration of Dakin's solution during irrigation. It was believed that bismuth-oil injections should not be undertaken when the cavity communicated with the bronchial tree, but in some instances, as shown in Figure 35, the bronchi leading from the fistulæ were found filled with bismuth when there had been no previous indication that a communication existed. The bismuth either outlined the bronchi clearly or was disseminated throughout the affected lung; there were no untoward effects from the procedure. Pastes were also employed with highly satisfactory results for the localization of fistulæ because they were not scattered throughout the lung as frequently as the oily suspensions, but, in view of a number of cases which showed considerable amounts of opaque material in the lung parenchyma at long intervals after the cavity was injected, it was considered inadvisable to employ this procedure as a routine diagnostic measure. Beck has emphasized the precautions which should be observed in cases where pleurobronchial communications are known to exist.[8]

Early healing of cases beginning with a pneumococcus infection was more frequent than among those following hemolytic streptococcus pneumonia. The streptococcus cases went through a chronic period of drainage and contraction which lasted several months. Many of them finally formed a small sinus; others reached a stationary stage when they were still comparatively large, so that a fair percentage required thoracoplastic operations. When it was decided that surgical interference was the only means of treatment and that it would involve the removal of parts of several ribs, stereoscopic plates of the bismuth-filled cavities gave an accurate idea of the location of the cavities and supplied information as to the extent and character of the operation that would be necessary to bring about approximation of the chest wall and lung surface. The difficulty frequently experienced in localizing points within the thorax in relation to the body surface was obviated very largely by stereoscopic roentgenograms or by fixing a coarse wire screen to the chest wall in a manner described by Beck.

THE STUDY OF CONVALESCENT PATIENTS.

Roentgenograms obtained after the wounds were healed served a manifold purpose. They were necessary in many cases because physical examination was not conclusive in regard to the nature of the pathology which existed in the thorax, because the thickness of the pleura rendered physical examination difficult. This thickening of the pleura resulted in dullness and diminished fremitus at the base and near the site of thoracotomy. To distinguish between such pleural thickening and an accumulation of fluid in the closed sinus by physical examination alone was frequently impossible unless the fluid was purulent and the condition was accompanied by elevation of temperature and other systemic reactions. While the roentgenograms were not always decisive as to the nature of the existent pathology it was possible to choose the site for exploratory thoracentesis more intelligently after stereoscopic study.

Reaccumulations of pus often occurred in the healed sinus tract and usually were clinically evident from the local reaction and the bulging of the scar. When the sinus was small the roentgenograms did not show an increase in the shadow when compared with those made at previous exposures because there was usually much cicatricial tissue which obscured the small accumulation of fluid.

The reaccumulations in the larger sinuses were accompanied by less local reaction. The dullness and decreased fremitus which occurred over the old cavity were often diagnostic, of course, especially if the temperature were elevated. Roentgenograms of these large recurrences showed dense shadows with sharply defined margins which did not resemble the diffuse shadow of moderate density found with pleural adhesions and cicatrization alone. Futhermore, shadows due to adhesions usually increased in density toward the diaphragm, while those due to fluid were practically always in the upper parts of the thorax and corresponded to the sinus in direction and location. Roentgenograms of the unhealed cavity filled with bismuth and those obtained immediately after the wound had healed were valuable for comparison.

In nearly every healed empyema there was a remnant of the sinus which formed a blind closed pocket, so that it may be said that healing, in so far as it can be applied to these empyemata, signified that the sinus or cavity had been sterilized, or the discharge had so diminished that it was possible for the wound to close. The small sinuses extended only through the parietal wall and could not be discerned in roentgenograms. The larger sinus tracts were indistinguishable unless they were air-containing or were filled with exudate. Those containing air, which was retained on account of the wide separation of the visceral and parietal surfaces at the time the drainage tubes were removed, when the external wound was allowed to close, pursued one of two courses. Usually the air was gradually absorbed and after many months the lung was approximated to the chest wall. The second possibility, which was in fact a rather rare occurrence, was that the closed, air-containing cavity communicated with the bronchial tree and instead of decreasing in size appeared larger in later roentgenograms. Occasionally such cavities were reinfected through the fistulous communication and, if exudate accumulated, showed a shifting fluid line. When fluid occurred, differentiation between serous and purulent exudates was impossible without exploratory thoracentesis. Serous fluids were absorbed and did not accumulate after having been once aspirated.

The roentgenograms of these closed cavities were interesting in respect to the character of the cicatrix over the lung surface and on the parietal wall. In roentgenograms obtained during the drainage of the cavities the parietal pleura was always several times thicker than that over the lung and, although it cast a moderate shadow, this shadow was never as dense as that of the cicatrix over the lung surface. Later, when the cavity had healed, this parietal layer was very frequently so transparent that on cursory examination it resembled an air-containing cavity. These pleural shadows differed in certain respects from an encapsulated pneumothorax so that in stereo-roentgenograms differentiation was always possible. The semitransparent area was always wedge-shaped with the base near the diaphragm and the apex of the wedge near the apex of the lung; furthermore, the density of the shadow was found to be similar to that of the tissue between the ribs and was not as clear as that of a pneumothorax. No explanation was found which might account for the transparency of the thick parietal pleura.

Roentgenograms following pneumococcus infections showed a normal lung parenchyma, but those obtained after hemolytic streptococcus bronchopneumonia and empyema indicate that there is a residual thickening of the septa

FIG. 51.—A healed pneumothorax due to a patent pleuropulmonary communication.

FIG. 52.—Healed empyema showing a moderate elevation of the diaphragm on the affected side, and compensatory expansion of the opposite lung.

Fig. 53.—Postoperative empyema following streptococcus pneumonia, showing the characteristic lung markings following the infection.

Fig. 54.—Healed empyema with an adherent diaphragm and dilated bronchi at the site of the healed wound.

FIG. 55.—Postoperative empyema with a thickened interlobar septum, thickened pleura, and an active tuberculous lesion at the right apex.

and interstitial tissues which persist as long as it is practicable to follow the cases. After intervals of one or two years, the septa could be traced from the bronchi outward to the margin of the lung. They were always more prominent in the affected lung. These markings differed from the delicate fan-like apical lesions of tuberculosis or the patchy mottled appearance of a tuberculous bronchopneumonia in that their distribution was throughout the whole lung area, and the lines were discrete and fine and radiated outward through perfectly aerated lung. No change has been found to occur in radiograms taken at various intervals during convalesence. Dense nodules have been found along the course of these markings in a large percentage of the cases with greater frequency than they have occurred in the lungs of patients without a history of streptococcus pneumonia. Unfortunately it was impossible to obtain plates of these men taken before the pneumonia, so it can not be said definitely that they did not exist prior to the infection. In the absence of a tuberculous history, both before and after the pneumonia, it was believed that they might represent interstitial changes in the glands and lung parenchyma incident to the pneumonia.

A diffuse, basal bronchiectasis with markedly thickened bronchi was observed after many of the infections. It was usually confined to the lower lobe after a combined infection with hemolytic streptococcus and Pfeiffer's bacillus. The bronchi and smaller air passages appeared thickened and could be traced out to the lung margin through the shadow of the lung substance, while the adjacent lung appeared mottled and patchy. This lesion was especially common in roentgenograms of patients convalescent from bronchopneumonia secondary to influenza. It was frequently confused with tuberculosis or with the inflammatory reaction surrounding abscesses or paravertebral pus pockets. In rare instances tuberculosis developed in these bronchiectatic areas after intervals of two or three years without modifying the picture in such a way that the diagnosis could be made until the process was well advanced. Apical bronchiectatic lesions have occurred in postinfluenzal cases, but since these lesions were not roentgenologically distinctive they were considered tuberculous.

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CHAPTER VI.

CLINICAL ASPECTS OF STREPTOCOCCUS PNEUMONIA AND EMPYEMA.

EPIDEMIOLOGIC CONDITIONS PREDISPOSING TO INFECTION WITH HEMOLYTIC STREPTOCOCCI.

Although empyema occurred in a small percentage of the military personnel before the induction of men fresh from civil life to make up the National Army, it was not until these recruits were gathered together in the camps that the morbidity and mortality rates for empyema were markedly increased. The empyema which had been common in civil life was usually due to pneumococci. The morbidity and mortality rates for pneumococcus infections were low, but as soon as the camps were filled with new men, infections with hemolytic streptococci were most common. This type of infection had occurred before during military operations. It was prevalent during the War of 1812, and, according to MacCallum,[1] probably occurred as a sequela of measles during the Civil War. In civil life hemolytic streptococcus pneumonia-empyema was recognized as a frequent and much feared complication of measles in children. At times it had been epidemic in parts of the United States. It appears that immediately before the mobilization of the Army these minor epidemics were more common than they had been in previous years.

Cases of hemolytic streptococcus pneumonia and pleuritis probably occurred in the Regular Army before the last few months of 1917, but it was not until late in that year that they were sufficiently numerous to attract general attention.[2] Pleuritis of unusual severity was observed along the Mexican border among troops of the Regular Army and the National Guard. This was before the World War. The pneumonia and pleural infections were so severe in these cases that the operative risk was great. Early in 1917 aspiration was adopted as a routine measure preliminary to operation. This method of treatment was suggested at that time by Keller[3] on account of the high mortality rate following surgical drainage of the pleural cavity during the first few days of illness. From the descriptions of these cases it is probable that they were similar in every respect to the cases which were observed later in the military camps during the mobilization of the National Army.

The first camps in which any great number of cases of empyema occurred were Beauregard and Wheeler. These camps were composed largely of men drafted from the rural districts of the Southern States. The epidemics of pneumonia in these camps were preceded in each instance by an epidemic of measles, and as pneumonia became more prevalent the incidence of empyema increased. In many of these cases empyema followed lobar pneumonia but the majority of them were secondary to hemolytic streptococcus bronchopneumonia. The first cases of streptococcus infection which occurred were apparently as severe as those which occurred two or three months after the epidemic began when the morbidity rate per thousand men had reached its highest peak. Later, in the spring of 1918, a few cases occurred in the northern camps, but, except in a few instances, they were scattered and the disease did not assume epidemic proportions.

In those camps in which streptococcus pneumonia was prevalent diseases of the upper respiratory tract were common and the plotted curves of the ratios (Chap. II) of the pulmonary and common respiratory diseases per 1,000 men show that pulmonary and common respiratory infections had the same seasonal variations and that the ratios of their incidence were practically parallel during various periods of the year. In a few isolated instances bacteriologic surveys showed that hemolytic streptococci were responsible for a fair percentage of the cases under this heading.

On account of the statistics from camps such as Camp Custer, where measles apparently played a very subordinate part as a factor predisposing to infection with hemolytic streptococci, and from camps such as Camp Dodge, where the cases were more equally distributed in regard to the predisposing infection—that is, between measles and other common respiratory diseases—it is evident that measles was not the only factor in the dissemination of hemolytic streptococcus infection. It does appear, however, that the majority of the first cases in the southern camps followed this exanthem and it is probable that on account of the large number of cases which developed, the virulence of the streptococci was enhanced and that the number of carriers was markedly increased in these localities.

The increased number of carriers undoubtedly had a great influence on the number of new cases. When the epidemic first began the infection was probably direct, in the sense that cases of respiratory disease were placed side by side in the wards of the hospital, and, on account of the ease with which streptococci pass from one individual to another, a case of streptococcus tonsillitis could be responsible for the direct infection of several other individuals. In the same way, a single streptococcus bronchopneumonia in a measles ward might result in the infection of several other patients. Cases once infected were prone to carry the bacteria in their throats for a lengthy period. The most rigid antiseptic treatment of the fauces was of little avail in terminating the carrier state.[4] These carriers were sources of infection and distributed the bacteria among normal patients as well as among patients with the simpler, common respiratory diseases. A vicious circle was established by this constant association of healthy men, carriers, and infected patients. Patients with the mildest respiratory diseases were constantly in contact with sources of streptococcus infection, and pneumonia was naturally more common on account of these contacts. The rôle which the increasing virulence of the bacteria may have played can not be determined.

Bacteriologic surveys of wards during the winter of 1917 and 1918 showed that streptococci could be disseminated throughout a ward from a single infected case. This was not only true for wards of patients in which there were streptococcus lung infections, but it was equally true for wards of patients in which there were carriers of streptococci only. These surveys showed that when carriers or cases of bronchopneumonia due to hemolytic streptococci were admitted to wards previously free from streptococcus infection, within a few days streptococci could be found in the throats of the majority of the other patients. When this occurred in measles wards, cases of pulmonary infection subsequently developed. The practical application of this observation was carried out at Fort Sam Houston during February, March, and April

of 1918. All cases of the exanthemata were held in an observation ward until the diagnosis was made. During the 24 or 48 hours that the patients were under observation for diagnosis, throat cultures were made to determine the cases already infected with streptococci. Those not infected with streptococci were isolated from those who were already carriers. The pulmonary complications following rubella were so infrequent that segregation of the carriers was not necessary. This simple precaution resulted in a definite decrease in the number of secondary complications after measles. The results of these surveys have been published by Cole and MacCallum,[5] and by Clendenning.[6]

The percentage of carriers among the personnel of the camps and hospitals varied according to the season and according to the local prevalence of streptococcus infections. No general surveys were made during the winter of 1917 and 1918, but during the epidemic of influenza in 1918 and 1919 a survey which illustrates some of these variations was carried out at Walter Reed General Hospital in Washington, D. C.[7] There were two waves of influenza at this hospital. The first wave occurred during October and November, 1918, and the second during January, February, and March, 1919. There were few streptococcus infections previous to January, but during the latter half of this month and during February, infections with hemolytic streptococci were common. These infections were not confined to pulmonary conditions but included primary surgical infections and secondary infections of wounds. Such a circumstance would be expected only if there were an increase in the number of carriers as all infected cases were carefully isolated. The survey for throat carriers was begun at a time when influenza was on the decline, yet pulmonary streptococcus infections were at their height. Surprisingly enough the number of carriers among the normal individuals selected for study increased until the last of April when there was a sharp decline in the percentage. During the time that the percentage of normal throat carriers was increasing, influenza had practically died out and there were but occasional cases of bronchopneumonia, but there were numerous instances of infections with streptoccoci of primarily surgical nature. While it is impossible to draw too rigid conclusions from a single survey of this kind, certain facts stand out preeminently. First, it is apparent that the streptococci were unable to invade the lungs in the absence of a predisposing respiratory infection. This is evident, since during April, 1918, there were more normal carriers than at any previous period, but few cases of bronchopneumonia occurred. There was practically no influenza and little upper respiratory disease at this time. Second, the number of carriers was increased by contact between carriers and normal individuals not previously infected.

It would appear from the preceding considerations that the carriers and upper respiratory infections were responsible in a great measure for the epidemics of bronchopneumonia and that a study of these factors and their relations would explain the epidemiologic variations found in different camps. Previous experience in civil life had demonstrated the close association between measles and hemolytic streptococcus pneumonia, so that in camps in the Southern States where the two appeared almost simultaneously there is every reason to believe that, since measles was directly responsible for a large number of cases, it was the most important epidemiologic factor. The increase in the number

of carriers following such a widespread infection, together with the prevalence of other respiratory diseases, could account for the fact that streptococcus bronchopneumonia was not confined to cases of measles but followed other bronchial infections and occurred long after the epidemics of measles had subsided. In some of the northern cantonments there were but few cases of measles. In these camps the epidemic of streptococcus pneumonia began later than in camps where measles was the predominant primary infection. This situation can be compared to that at Walter Reed General Hospital where influenza was the primary respiratory disease. Pneumococcus infections were the most common but during the latter part of the epidemic there were numerous cases of streptococcus bronchopneumonia. It was a universal observation that measles predisposed to an early epidemic of streptococcus pneumonia,

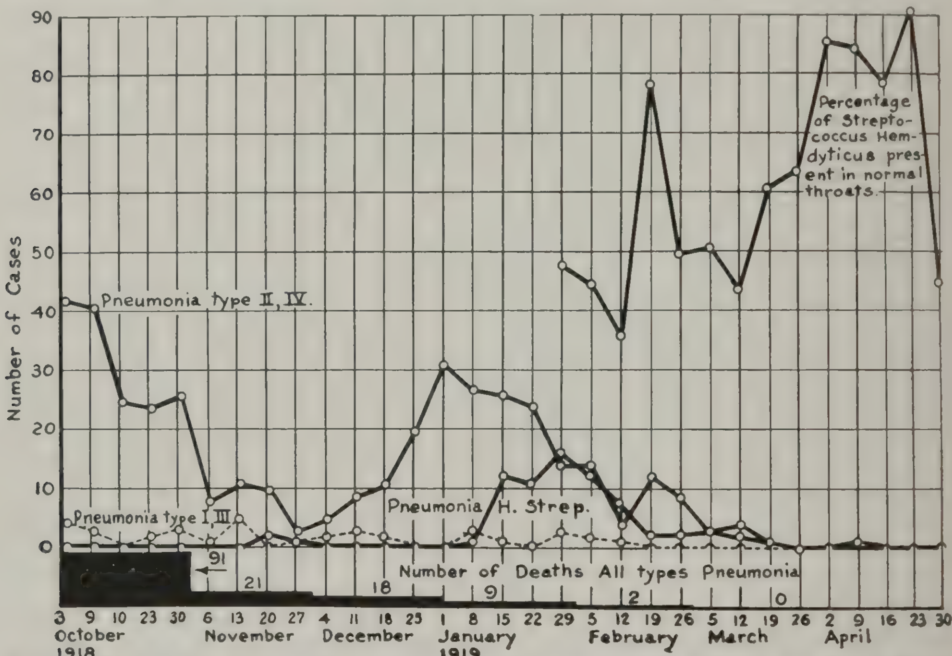

CHART LXIV.—Carriers of streptococci following the epidemic of influenza in 1918–19, Walter Reed General Hospital. Washington, D. C. This chart, as well as Charts LXVIII, LXIX, LXX, and LXXI, have been reproduced through the courtesy of the *Journal of the American Medical Association.*

while epidemics of other bronchial infections might or might not be accompanied by the disease. If it occurred it came late in the epidemic.

SYMPTOMATOLOGY AND PHYSICAL SIGNS.

Streptococcus bronchopneumonia and pleuritis were usually secondary in the sense that they followed a primary upper respiratory infection. In some camps the majority of the infections followed measles while in others tonsillitis, bronchitis, and pharyngitis preceded most of the cases. In many instances it was difficult to elicit a history of respiratory disease. The patients often gave a history of cough, headache, and malaise for a few days preceding the onset of the pneumonia. Nosebleed was common in this type of infection. In some cases the onset was sudden, with intense pleural pain and fever, but a careful study of the cases showed that there had been predisposing respiratory disease.

The symptoms at the time of onset varied according to the localization of the infection. There were, in fact, two types of cases. In one type the pleura was predominantly involved throughout the course of the disease. In the second type the pneumonia was the most striking feature. Cases with evidence of early pleural irritation were most common after tonsillitis, bronchitis, pharyngitis, or mumps. They even occurred without a history of a preceding respiratory disease. There were pleural pain, fever, nausea, and vomiting. The onset was occasionally accompanied by chill, but less frequently than in lobar pneumonia. The exudate usually developed early and occurred in large quantities. Cases of the second type began with an aggravation of the symptoms of the preceding infection. When the pneumonia followed measles a secondary rise in temperature was observed between the third and the seventh days after the rash appeared. These infections were most frequently seen when the measles had been accompanied by a severe bronchitis. The bronchitis became more severe with the rise in temperature, the râles over the bases were more numerous and liquid, and the cough was aggravated. Chills were not frequent in this type of case and pleural pain was not a striking feature. While the majority of the cases belonged distinctly to one of these types, cases were observed in which both the pneumonia and pleuritis were severe in the first few days of the infection.

When the pneumonia was fully developed the respiratory distress was the most striking feature of the disease. Respiratory embarrassment was not marked when the pneumonia was not extensive and the infection was confined mostly to the pleura. The respirations were always shallow at the onset when there was much pleural irritation, but as soon as the pain subsided they assumed a more normal character. When the pneumonia was extensive in both lungs the respiration was rapid, shallow, and labored. The patients were restless and anxious. There was marked inspiratory and expiratory embarrassment, so that the accessory muscles of respiration were brought into play and the alæ nasi contracted sharply with each inspiration. The respirations were usually 40 to 60 per minute. There was constant, exhausting productive cough with large amounts of frothy mucopurulent sputum. After a severe paroxysm of coughing, the patient was drenched with sweat, the respirations were shallow and rapid and the face was flushed or cyanotic. Cyanosis was common during the later stages of the disease.

During the first two weeks of the disease, the temperature in the majority of the cases averaged 102° to 104° F. When the infection was predominantly pleural it was usually continuous for the first few days after the onset, with daily variations of only one-half to one degree. As soon as the pneumonia was fully developed the differences between the morning and evening readings were more marked, and they were frequently as great as 3°. In certain cases the pneumonia was never extensive but there were large quantities of pleural exudate. In these instances the temperature was usually highest at the time the exudate was first formed. After each aspiration it would fall 1° to 3°, but would rise again as more fluid was produced. This irregular temperature curve continued until the time of operation.

These daily variations in temperature were usually most extreme when the patients were expectorating large quantities of mucopurulent sputum.

Occasionally there were drenching sweats, and after these sweats the temperature might be normal for several hours, but true crises were not observed in the streptococcus infections. The high fever persisted in the majority of cases from three to four weeks. During the third week the morning temperature might be normal, but evening elevations occurred for several weeks after the empyema had been drained and the bronchopneumonia had resolved.

The pulse was rapid and weak. Herpes occurred at times but was not seen as frequently as it was observed in lobar pneumonia. Vomiting and nausea were common during the first few days but seldom persisted beyond the first week. Abdominal distention was infrequent. The liver and spleen were seldom palpable. Jaundice, usually associated with tenderness over the liver, was observed both early in the course of the bronchopneumonia and immediately before death.

In cases of bronchopneumonia which were not complicated by an effusion at the onset there was moderate dullness over the consolidated lung. The râles were usually confined to the dull area and were at first fine and crepitant, but after the second or third day they were coarse and bubbling. In the cases following an acute bronchitis or measles several such areas were often observed on the first or second day of the pneumonia. As the pneumonia advanced these areas of dullness became confluent and râles were heard over the entire chest. The percussion note elicited was never as flat as that elicited over the consolidation of lobar pneumonia. The breath sounds were bronchovesicular or bronchial and they were often suppressed at the onset of the pneumonia. Tactile fremitus was diminished at first, but later was normal or slightly increased.

When a massive pleural effusion developed within the first few hours after the initial symptoms of cough and pleural pain the physical signs were often similar to those found in extensive lobar pneumonia. The percussion note over the affected lung was flat; the tactile fremitus was either increased or normal, rather than diminished, as would be expected with a large effusion; the breath sounds were either suppressed or bronchovesicular. Harsh bronchial breathing never occurred over massive effusions. There were, however, several signs which could be depended on in the majority of cases as differential points between consolidation and fluid. The most valuable sign was the cardiac displacement, which was extreme in these cases. This cardiac displacement was observed occasionally with complete consolidation of one lung, but in such cases was never more than 3 or 4 cm. The second differential sign was a tympanitic and hyperresonant percussion note below the clavicle on the side of the effusion. Hyperresonance occurred at the apex of the lung with consolidation of a lower lobe, but the percussion note was never tympanitic.

The signs associated with large effusions were usually less confusing than were those occurring when small amounts of fluid were encapsulated at the apex or at the base of the lung near the large bronchi. Collections of exudate in these regions usually gave increased tactile fremitus, dullness, and harsh bronchial breathing. Fluoroscopic examination or Roentgen-ray plates were valuable, but aspiration was the only positive means of diagnosis. Diagnosis was especially difficult when the exudate occurred late in the pneumonia, because the pus was often pocketed between the lobes of the lung, between the lung

and the pericardium, or along the mediastinal wall. Roentgen-ray examinations were essential in locating these encapsulations before diagnostic aspiration was attempted.

The sputum was usually thick, mucopurulent, and tenacious, and at times was blood streaked. It was especially copious in the cases of extensive bronchopneumonia secondary to the bronchitis of measles. In cases with a predominant pleural infection there was little sputum during the first week of the illness. The quantity of sputum was usually an index of the extent of the pneumonic process. When the patients developed bronchiectasis, a lung abscess, or, when pus was encapsulated in some obscure pocket, the cough and sputum were prominent features of convalescence. From the washed sputum of the convalescent patients having these complications pure cultures of hemolytic streptococci were commonly obtained.

In practically every case of empyema there was a leucocytosis of from 15,000 to 30,000. The polymorphonuclear neutrophiles were usually increased to about 80 to 85 per cent, and the small mononuclears averaged 5 to 15 per cent. In cases following measles 10 to 15 per cent of transitionals and large mononuclears were frequently observed. The leucocyte count was usually 12,000 to 15,000 in those cases in which pus had been present for some time. The differential count was often normal. Occasionally normal counts were observed in febrile patients with undiscovered pleural pockets of pus. When streptococcus bronchopneumonia and empyema followed influenza a leucopenia was the rule. In severe cases of influenza in which the leucocyte count was low (2,000 to 3,000) before the pneumonia developed the count was not usually influenced by the secondary infection of the lung. Occasionally during the second week of the pneumonia the leucocytes would reach 8,000 to 12,000. The count seldom exceeded 15,000. The differential count was either normal or there was a decided lymphocytosis (40 to 60 per cent). Anemia was never a prominent feature of the acute cases, but was common in long continued cases with undiscovered pleural foci.

The urine was small in amount during the height of the fever. There were usually traces of albumin and a few hyaline and granular casts. Red cells were found occasionally.

CONDITIONS ASSOCIATED WITH EMPYEMA.

In the chapter on pathology a study of the available autopsy material showed that, in the majority of the fatal cases, the infection had extended beyond the lung and pleura affected at the onset and that multiple foci occurred throughout the body. It would hardly be proper to speak of these secondary infections as complications of the pleuritis, since the pleuritis was in fact secondary to the pneumonia and was but an expression of the avidity with which the bacteria spread from the lung to the adjacent tissues. Since the pneumonia was the primary focus from which the bacteria were disseminated, infections of the pericardium, peritoneum, and viscera have been termed "conditions associated with empyema." In rare instances the pericardium was probably infected by a direct extension from the pleura overlying the pericardial sac. When the infection took place by this route the pericarditis was in the strictest sense secondary to the pleuritis. Exceptions such as this, however, occurred

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only when viscera immediately contiguous to the pleural surface were invaded. In some instances resolution of the pneumonia was undoubtedly delayed on account of the pleural infection and secondary foci developed late during the course of the disease.

Bilateral pneumonia and empyema were associated in 29.64 per cent of all the cases with a resultant mortality of 49.4 per cent. The association of these conditions was most common during the first four weeks of the disease. It occurred in approximately 70 per cent of the fatal cases dying within this period, 40 per cent of which were associated with a unilateral empyema. In the remaining 60 per cent both pleural cavities were infected. The mortality was much higher in the cases with streptococcus pneumonia. Of the cases which had bilateral pneumonia and unilateral empyema due to streptococci 42.2 per cent died. When both pleurae were involved the mortality was 89.1 per cent. Unilateral empyema and bilateral lobar (pneumococcus) pneumonia had a mortality of 21.6 per cent. When the empyema was bilateral the mortality was 78.3 per cent. Bilateral staphylococcus pneumonia-empyema was invariably fatal.[8]

There were two types of cases with these associated conditions. In the first type of infection the process was so rapid that both lungs and pleuræ were involved within the first four days after the onset of the pneumonia. This course was rather to be expected among the cases which began with intense pleural pain and an audible friction sound. The exudate in the pleural cavity first affected was usually large and measured from 1 to 3 liters. The opposite cavity contained smaller amounts because the blood stream was usually invaded and death occurred before large quantities were produced. Pericarditis occurred frequently, but the diagnosis was not always made because the effusions were small and the inflammatory reaction often did not progress beyond the serofibrinous stage. Occasionally a friction rub, synchronous with the heart beat, was audible over the precordium. The patients complained of intense precordial or abdominal pain. In the second type of case the course was not as rapid, and, especially when the bronchopneumonia was secondary to measles or influenza, extension proceeded in a more leisurely manner. Both lungs were often affected before the exudate was formed, the pneumonia being recognizable in the beginning by patches of râles, consolidation, and bronchial breathing. These patches coalesced, the dullness over the involved areas increased and the breath sounds became distant. The pleural cavities were not involved simultaneously. Aspiration often yielded only a few hundred cubic centimeters of seropurulent fluid. While the prognosis was exceedingly poor in bilateral pneumonia and empyema when both cavities were infected, the later type of case, in which there was an interval of several days between the time that the first cavity was infected and the opposite cavity was involved, offered a better opportunity for treatment. The pus was aspirated until the pneumonia had subsided. The closed method of aspiration through a stab wound was especially valuable, as this method offered an opportunity for frequently emptying the cavities without disturbing the patient. The lungs could be kept expanded to their fullest capacity if the fluid was withdrawn at intervals of four or five hours.

Bilateral empyema was most common during the fifth week of the pneumonia. It was always associated with an active pulmonary process in both

lungs in those cases in which the two pleural cavities were infected within a period of a few days. When the interval between the beginning of the infections on the two sides was greater than two weeks the pneumonia on the side primarily affected had usually resolved before the second empyema occurred. The incidence of these bilateral infections was much lower after the fifth week. Bilateral infections occurred in about 1.3 per cent of the cases which recovered and in 23 per cent of the fatal infections. The mortality was 89.7, 79.7, and 100 per cent, respectively, among the streptococcus, pneumococcus, and staphylococcus cases.

Pericarditis was especially common among the cases which died after the first few days of the disease. It occurred in 1.5 per cent of the living cases and in 18.7 per cent of those dying before the eighth week after the onset of the pneumonia. The mortality was 85.8 per cent among the cases in which it occurred. It was associated most commonly with a bilateral streptococcus pneumonia and empyema. Peculiarly enough, pericarditis was rare before the fourth or fifth day of the infection. Apparently, even in the most fulminating cases with bilateral pneumonia and empyema, which developed with great rapidity, the extension of the infection was not sufficiently rapid to reach the pericardium before the patients died. After the first week pericarditis was increasingly frequent. The symptoms were often masked by the pneumonia and the presence of fluid so that a diagnosis was difficult, but the one outstanding symptom was precordial pain, which occurred in a majority of these patients and was associated with a pericardial rub. This rub was of a to-and-fro character and in most instances it was transient, but if it persisted for several days the prognosis was better than when it was heard only at the onset of the pericarditis. It would seem that in the instances in which the pericardial infection did not progress beyond the fibrinous stage the process was self-limited, but when exudate was formed in amounts which would render the rub inaudible the process went on to pus formation. The blood cultures were usually positive in these cases. In some instances the pericardium was infected before the blood stream had been invaded. The pericardial exudates were small and in the majority of instances the condition of the patients did not warrant surgical drainage. In a limited number of cases, in which the pericarditis occurred so late in the course of the infection that the pneumonia had resolved, the sac was drained through a wide apical incision. A few of these cases recovered from the infection but died after an interval of several months from cardiac dilatation and insufficiency.

Although peritonitis was found at autopsy in fully 20 per cent of the cases, it occurred in only 2.8 per cent of the total number of empyema cases. The peritoneum was invariably infected after the pneumonia had extended to both lungs and there was clinical evidence of a pericarditis. It was uncommon before the fourth day of the disease. The symptoms and physical findings were inconstant. When the patients were not moribund they complained of abdominal pain which was often definitely localized in the upper quadrants of the abdomen; audible friction rubs were common over the liver and spleen; and there were rigidity and tenderness. The mortality was 97.3 per cent among the cases in which this complication occurred. The blood cultures were always positive.

The thoracic conditions associated with empyema were, of course, more common than the conditions involving other viscera. Aside from peritonitis, extrathoracic complications were infrequent. Endocarditis, erysipelas, arthritis, phlebitis, multiple abscesses, mastoiditis, otitis media, and meningitis were observed in a small percentage of the cases. Endocarditis and meningitis were always fatal. The remainder of the complications mentioned were found as frequently among the cases which survived as among those which died, and so can not be considered as conditions directly responsible for death.

One of the most common of the extrathoracic conditions was the tendency to multiple streptococcus abscesses of the muscles and fasciæ. The abscesses were most common in the epigastrium in the sheath of the rectus muscle, and were seen less frequently in the pectoral muscles or in the subcutaneous tissues. They usually occurred in the course of streptococcus pneumonia, but repeated blood cultures on these cases failed to demonstrate a bacteriemia. They were not confined, however, to cases of empyema and pneumonia, but were observed, at times, in septicemia following a primary phlegmon due to hemolytic streptococci.

GENERAL CONSIDERATIONS OF TREATMENT.

The treatment of these cases of bronchopneumonia and empyema was modified to a great extent during the spring of 1918. Until that time no distinction had been made between the treatment of empyema following lobar pneumonia and that occurring during the course of a streptococcus bronchopneumonia. The same principle had been followed in either case; and, regardless of the fact that the two conditions were pathologically and clinically distinct entities requiring different procedures, all the cases were surgically drained by thoracotomy or rib resection as soon as the diagnosis of empyema was made. The infections differed in two respects. First, the course of streptococcus bronchopneumonia extended over weeks while the acute stage of the pneumococcus infections was limited to a period of several days and was terminated in most instances by a crisis. After the crises the patients could be operated on without danger. Second, the streptococcus effusions were large and occurred during the height of the pulmonary infection; while those due to pneumococci were small, were encapsulated, and were diagnosed after the crisis in at least 80 per cent of the cases.

On account of the severity of the infection and the high mortality among cases of bronchopneumonia it was felt that palliative measures might bridge over the acute stage of the pneumonia until a time when the patients would be better operative risks, and that the risk would then be no greater than that taken when cases of empyema following lobar pneumonia were operated on within two or three days after the crisis. In 1917, Keller[3] had suggested that if the effusions were aspirated for several days the shock at operation might be less severe. He carried out this procedure in a few cases with excellent results. Aspiration was again attempted at Camp Dodge early in 1918. In April, 1918, a commission was appointed by the Surgeon General of the Army to study the question of treatment.[9] This commission found, however, that other measures were required in addition to those already suggested. The results of the study, which was carried out at Camp Lee, Va.,

were published during the summer of 1918 and served as a guide for the treatment of the cases occurring after that time. The material in this report has been used freely in the following paragraphs.

ASPIRATION OF INFECTED PLEURAL EFFUSIONS.

When streptococcus pneumonia and empyema first occurred in the Army camps it was customary to drain the effusions immediately the diagnosis was made. An operation undertaken at this time meant that the patients must be subjected to the shock of operation at a time when they were not fit surgical risks. They were poor risks for several reasons. First, the pleuritis occurred either at the onset of the pulmonary infection or during the course of an extensive bronchopneumonia when the majority of the patients were dyspneic and cyanotic. The cyanosis and the dyspnea were always most striking in those cases in which there was an extensive parenchymal lung infection. In addition, the effusions were usually large and the adhesions between the lung and parietal wall were not sufficient during the first few days of the disease to prevent the collapse of the lung when the pleural cavity was opened. The collapse of the lung at operation still further diminished the already embarrassed pulmonary ventilation. This chain of circumstances, the extensive pneumonia, the large free effusion, and the collapse of the lung, was often immediately fatal. Second, the fever was usually at its maximum when the exudate was formed; in fact in many cases an elevation of one or two degrees was observed just at this time. The patients were sometimes delirious, and refused to take fluids by mouth. When the effusions were drained during this intensive toxemia, the delirium was often more marked and all nourishment and fluids were refused for the following two or three days. The increased dyspnea and the diminished food and fluid intake augmented the toxemia, so that no immediate benefit was derived from the operation. When the operations were delayed until the second or third week after the onset of the pneumonia, however, the condition of the patient was so much improved that drainage could be accomplished with less danger.

During the interval between the time that the pleuritis was first diagnosed and the time that the patient was in condition to withstand an operation the effusions were removed by aspiration. For this procedure a Potain apparatus was used. Three or four aspirations were usually required at intervals of one or two days. After the third or fourth aspiration the exudate, which was at first serous and straw colored, became thick, creamy, and purulent, and at times it could not be drawn through the needle. The quantities of fluid aspirated varied, the greatest quantities being usually obtained in each case at the second or third aspiration. The effusions were usually largest in cases in which the onset of the pleuritis was during the first week of the pneumonia. The amounts which were obtained often varied greatly on different days, because adhesions and encapsulations would be so formed that parts of the cavity could not be emptied. The quantities of exudate and the intervals between aspirations in 10 typical cases are shown in Chart LXV. The intervals are reckoned from the onset of the pneumonia. In some of these cases it can be seen that aspiration was not always successful, and that when the effusions were small, dry taps were common. Occasionally only a few cubic centimeters could be obtained.

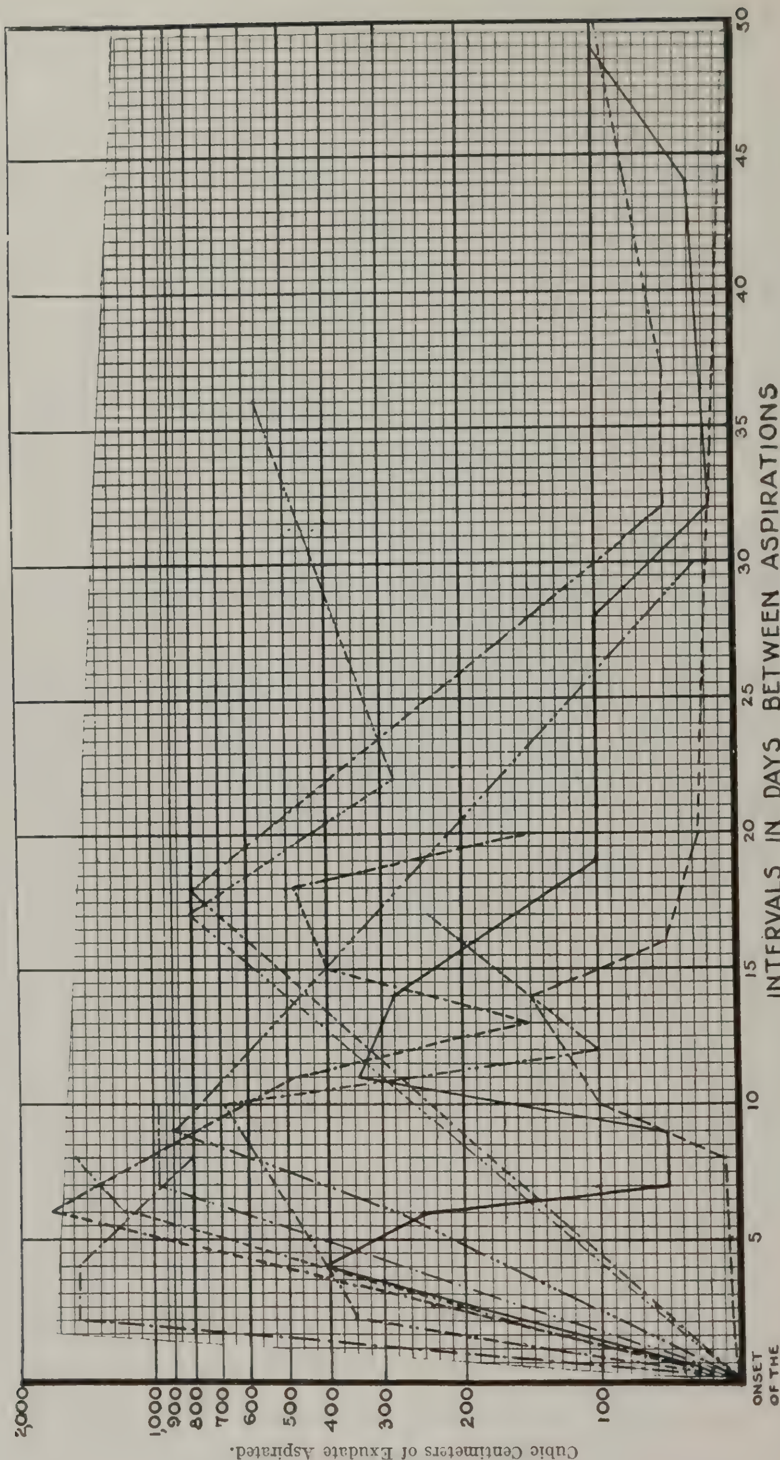

CHART LXV.—Aspiration of 10 typical cases of streptococcus pleuritis.

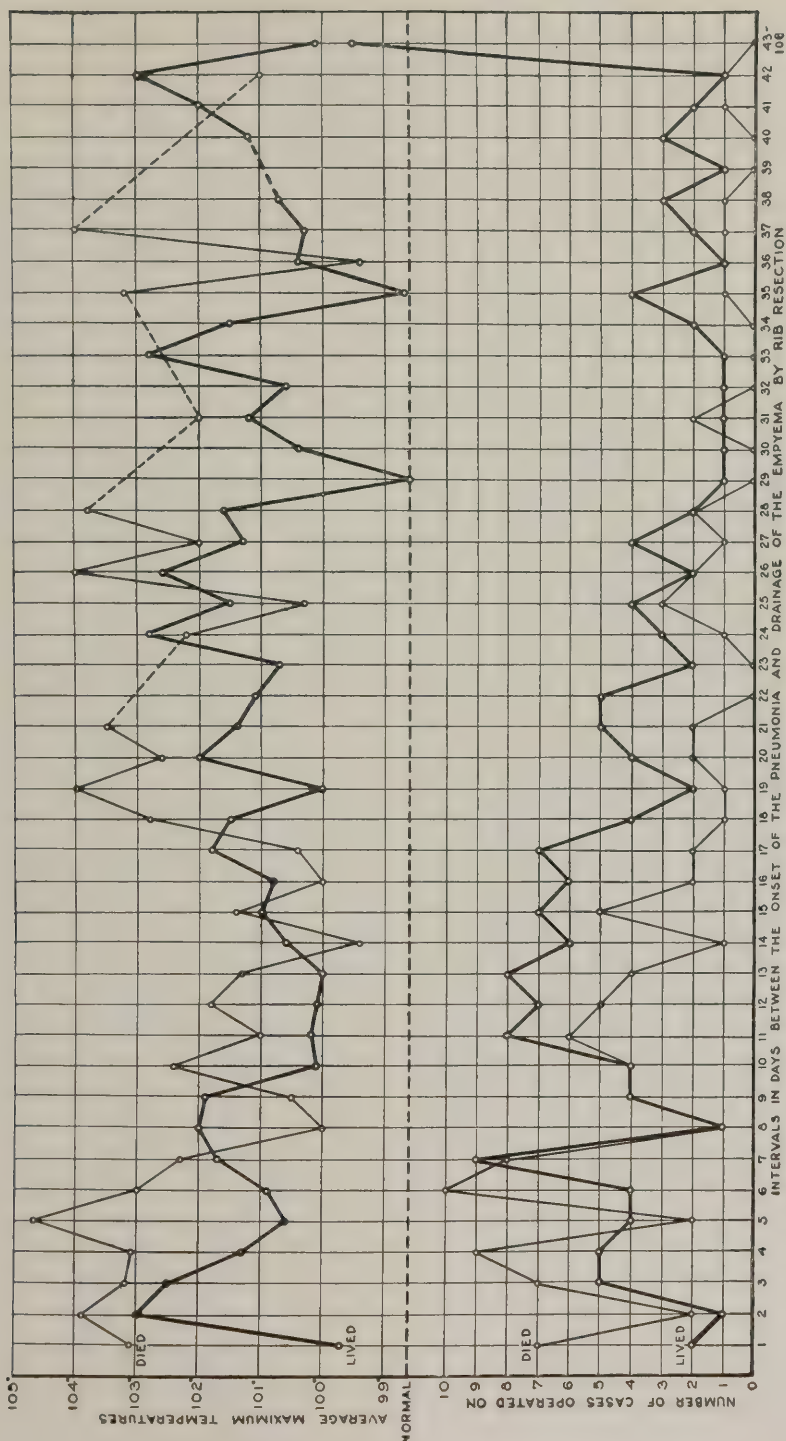

CHART LXVI.—Mortality following rib resection at varying intervals after onset of pneumonia.

Naturally the most important question was in regard to the time which was best suited for the surgical drainage of the empyema. This depended on the condition of the patient and on the character of the exudate obtained at aspiration. The patient was judged to be in fit condition for an operation when the bronchopneumonia was no longer active. From the physical signs alone it was impossible to be certain that the pneumonia was resolving, because dullness and coarse râles persisted in some cases for several weeks. The temperature, respirations, and pulse rate were the most reliable guides. When they showed a definite trend toward normal and the patients were no longer toxic, surgical drainage was usually carried out at once. The second criterion in regard to the time for operation was the character of the exudate. Operation was usually delayed until the exudate was no longer serous or serosanguineous, but was purulent and contained numerous fibrin flakes. It was thought from a study of the autopsies that when the fluid was purulent and contained numerous flakes of fibrin, adhesions had been formed between the visceral and parietal pleuræ which would prevent the collapse of the lung when the pleural cavity was opened. One of the indications for immediate operation was pyopneumothorax with symptoms of cardiac embarrassment. Frequently patients with pyopneumothorax were seen with cyanosis of the extremities, and an almost imperceptible pulse. In these cases aspiration was not as effective as immediate drainage for the relief of the symptoms.

A statistical study of cases of empyema which came to operation shows that the end of the second week after the onset of the pneumonia was probably most favorable for surgical intervention. A series of 264 cases has been chosen for this study. One hundred and two of the cases died within a few days after the operation, while the remaining 162 recovered. Since the mortality is about 40 per cent (approximately the mortality among the total number of cases of pneumonia associated with empyema in the Army), it is fair to assume that these cases represent a fair section of the entire epidemic. When these cases are charted according to the interval between the onset of the pneumonia and the drainage of the empyema by rib resection, it is observed that the majority of the patients who were operated on during the first week of the disease died, while the majority of those operated on during the second and third weeks lived. The highest point of the mortality curve falls on the seventh day, while the highest point foı the living cases occurs at the end of the second week. Now, if the mortality following operation is compared with the average temperatures on the days the operations were done several interesting points are at once apparent. First, the average temperatures on the days of the operations were higher among the patients who died than among the patients who lived. Second, the maximum mortality and the peak of the temperature curve fall about the seventh day of the pneumonia. Third, the lowest average temperatures occurred about 14 days after the disease, when the mortality after operation was lowest. The conclusions to be reached from these points are obvious. The temperatures indicate that the infections were most acute during the first week of the disease and that operations were most often fatal during this interval when the high fever indicated an active pneumonia. During the second and third weeks the lower temperatures indicated

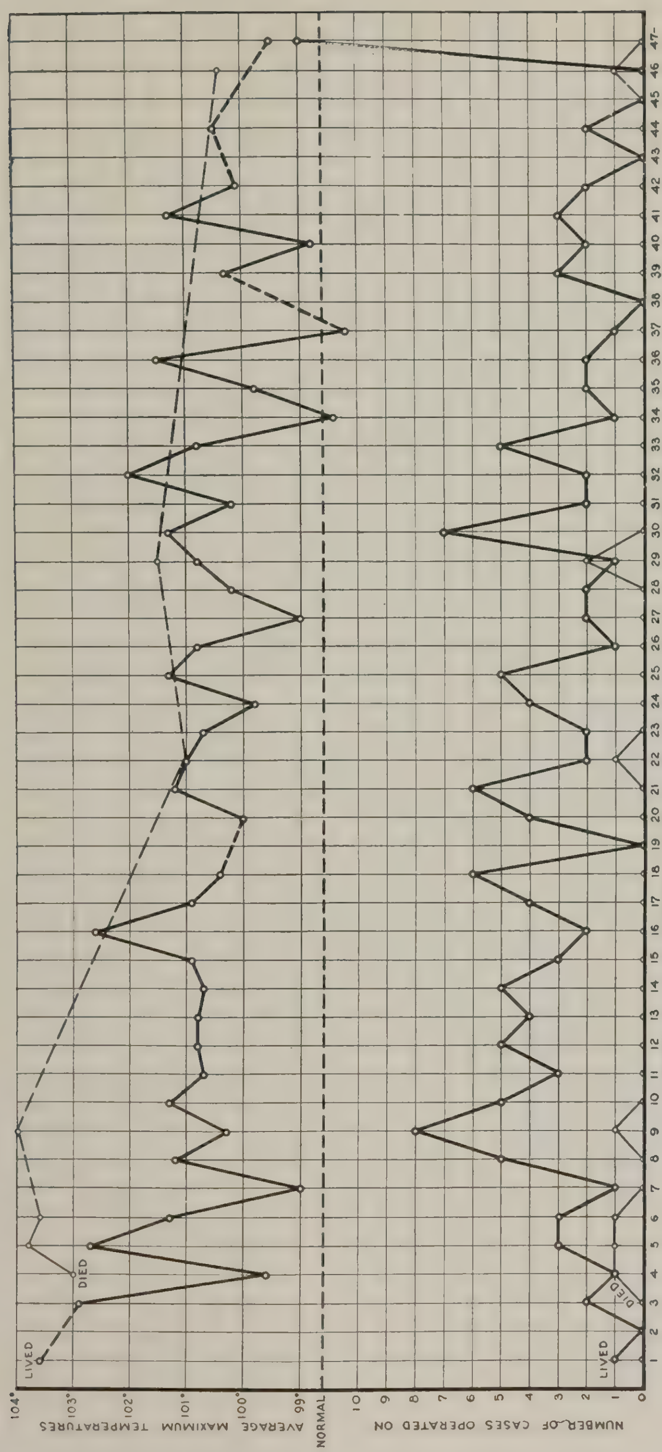

CHART LXVII.—Mortality following catheter drainage begun at varying intervals after onset of pneumonia.

that the pulmonary infection was subsiding. This was also the most favorable time for operation. The high temperatures observed on the day of operation after the second week of the disease were probably due to the pleural infection and not to the pneumonia. It is difficult, however, to refute the argument that the majority of the fatalities occurred early in the course of the infection, regardless of operation, and that the grouping of the fatal postoperative cases in the first week might be accounted for in this way.

There is no way in which the records of the patients in the Army camps can be used to establish beyond question the value of a delayed operation in lowering the mortality rate. Although the reports of the Camp Lee commission and the reports from Camp Pike, where aspiration by trocar and canula was resorted to, show that the mortality was lower in the groups of cases treated in this way than among those treated by immediate operation, the cases treated by preliminary aspiration occurred during the last few weeks of the epidemic, when the severity of the infection was subsiding, or were mild infections scattered throughout the spring and summer months of 1918. In Chart LXVII is a series of cases treated by catheter drainage and with antiseptics. This series shows that, although the mortality was low in the 144 cases which have been collected for study, the average temperatures on the day of aspiration would indicate that the cases were relatively mild. No extensive studies were carried out during the same epidemiologic period comparing the effects of immediate and delayed operation.

Delayed operation was not considered necessary in empyema complicating lobar pneumonia, for the condition of these patients was such that they were usually good surgical risks when the diagnosis was made. When the exudate was discovered before the crisis, preliminary aspiration was considered to be the logical treatment.

NUTRITION.

Among the most profitable undertakings of the commission at Camp Lee[9] was a study of the nitrogen output of patients in the early stages of empyema associated with the hemolytic streptococcus. It was a common observation that these patients became emaciated and lost strength with great rapidity, and that generous feeding should be a part of their treatment. The amount of nitrogen lost, however, had not been clearly defined.

In spite of some difficulty in obtaining proper chemical equipment, fairly satisfactory determinations of total nitrogen in the urine and exudate were made in three representative cases.[9]

The nutrition of several cases was studied in detail by means of their nitrogen balance. The food consumed was accurately weighed and the fuel value and the nitrogen content calculated from the tables of Atwater and Bryant. The urine was collected in 24-hour periods, and its nitrogen content determined by the method of Kjeldahl. The daily excretion of nitrogen into the pleural cavity was obtained by measuring and analyzing the exudate each time the patient was aspirated. After operation, the exudate could not be collected and the daily pleural nitrogen excretion was assumed to be the same as just before operation. Since the daily amount of nitrogen in the exudate was not over 2.5 gm. per day, this assumption involves no serious error.

The nitrogen of the feces is disregarded, and for this reason the nitrogen balances given are slightly too favorable.

In Tables 52, 53, and 54 the nitrogen intake and output of three patients are given. Complete 24-hour specimens of urine could not always be obtained and figures are omitted on such days.

TABLE 52.—*Food intake and nitrogen balance, Case I.*

Period ending 9 a. m.	Food.		Urine.		Exudate.				Nitrogen balance.
	Calories.	Grams, nitrogen.	Volume, c. c.	Grams, nitrogen.	Volume, c. c.	Nitrogen.			
						Per cent.	Grams.	Grams, day.	
Apr. 28	1,408	9.7	1,000	16.4		0.747			− 8.7
Apr. 29	1,758	11.9	2,050	31.7					−21.8
Apr. 30	1,160	9.0	1,925	19.9	540	.741	4.0	2.0	−12.9
May 1	2,210	14.6	2,250	21.0					− 7.2
May 2	3,732	24.0	2,915	16.9	215	.711	1.5	.8	+ 6.4
May 3	3,322	23.2	3,030	13.0					+ 8.5
May 4	2,955	20.2	3,060	16.2	480	.691	3.3	1.7	+ 2.3
May 5	3,573	25.3	2,740	19.6					+ 4.1
May 6	3,837	22.2	1,500	14.2	360	.869	3.1	1.6	+ 6.4
May 7	3,108	23.3	1,770	18.1					+ 3.9
May 8	3,288	22.2	2,050	18.8					+ 2.1
May 9	3,780	26.5			345	1.158	4.0	1.3	
May 10	3,347	21.7	1,750	19.1					+ 1.3
May 11	3,662	25.6	1,640	19.3	220	1.201	2.6	1.3	+ 5.0
May 12	2,793	16.9	1,490	17.0					+ 1.4
May 13	3,510	25.1	1,600	14.8					+ 9.1
May 14	1,679	11.0	1,590	17.2					− 7.5
May 15	464	3.4	250	3.2	Operated 3 p. m., May 14. These two days not properly separated.				− 7.7
May 16	2,444	16.3	1,560	29.3					+ 7.0
May 17	3,125	21.5	1,310	13.2					+ 7.0
May 18	2,794	18.0	1,310	10.4					+ 6.3
May 19	2,850	19.7							
May 20	2,807	18.3	1,700	14.6					+ 2.4
May 21	1,839	11.8							
May 22	2,194	13.2	1,710	19.3					− 7.4
May 23	2,503	14.5	1,520	15.8					− 2.6
May 24	2,577	17.3	2,200	18.4					− 2.4
May 25	2,518	17.4	1,210	9.7					+ 6.4
May 26	3,754	25.1	1,240	12.1					+11.7
May 27	3,156	20.4	1,700	15.5					+ 3.6
May 28	3,880	25.4	1,790	16.4					+ 7.7
May 29	3,969	23.4	1,800	14.6					+ 7.5
May 30	3,972	25.3	1,530	16.0					+ 8.3

TABLE 53.—*Food intake and nitrogen balance, Case II.*

Period ending 9 a. m.	Food.		Urine.		Nitrogen balance.	Period ending 9 a. m.	Food.		Urine.		Nitrogen balance.
	Calories.	Grams, nitrogen.	Volume, c. c.	Grams, nitrogen.			Calories.	Grams, nitrogen.	Volume, c. c.	Grams, nitrogen.	
May 17	2,136	12.8	2,980	21.3	−8.5	June 2	2,042	13.6	1,570	14.0	− 0.4
May 18	3,106	18.4	3,390	19.7	−1.3	June 3	2,666	16.2	1,350	14.3	+ 1.9
May 19	3,638	21.1	3,070	15.8	+5.3	June 4	3,490	25.4	2,050	14.6	+10.8
May 20	3,751	22.4	4,680	17.5	+4.9	June 5	3,017	17.9	2,200	14.0	+ 3.9
May 21	3,416	19.6	3,700	17.1	+2.5	June 6	2,095	12.7	2,650	16.1	− 3.4
May 22	3,205	15.8	2,880	18.2	−2.4	June 7	1,079	6.2	2,270	12.2	− 6.0
May 23	3,660	21.1	2,700	16.1	+5.1	June 8	1,600	10.5	990	8.7	+ 1.8
May 24	3,737	18.8	3,540	17.6	+1.2	June 9	2,295	11.0	1,180	9.5	+ 1.5
May 25	2,697	14.6	2,120	15.0	− .4	June 10	3,159	15.8	1,370	10.7	+ 5.1
May 26	3,220	16.3	2,940	15.5	+ .8	June 11	3,968	17.1	1,180	8.5	+ 8.6
May 27	2,512	13.1	1,700	13.6	− .5	June 12	2,956	17.2	1,390	11.0	+ 6.2
May 28	3,121	17.7	3,330	15.1	+2.6	June 13	3,208	14.8	1,570	11.6	+ 3.2
May 29	2,520	12.8	1,820	11.3	+1.5	June 14	3,356	15.8	1,300	9.4	+ 6.4
May 30	2,675	15.5	2,220	15.9	−0.5	June 15	3,495	18.8	1,040	9.8	+ 9.0
May 31	3,037	19.7	2,900	15.3	+4.4	June 16	3,562	19.3	1,160	10.7	+ 8.6
June 1	2,643	15.2	2,340	16.9	−1.7	June 17	3,630	19.1	980	9.5	+ 9.5

TABLE 54.—*Food intake and nitrogen balance, Case III.*

Period ending 9 a. m.	Food.		Urine.		Exudate.				Nitrogen balance.
	Calories.	Grams, nitrogen.	Volume, c. c.	Grams, nitrogen.	Volume, c. c.	Nitrogen.			
						Per cent.	Grams.	Grams, day.	
Apr. 28	1,408	9.7	3,030	20.3		0.827			12.9
Apr. 29	2,397	16.4	4,300	22.1					− 8.0
Apr. 30	1,745	10.6	4,900	22.2	595	.790	4.7	2.3	13.9
May 1	2,061	18.2	3,710	22.7					− 6.8
May 2	3,403	21.7	2,990	21.0	415	1.123	4.7	2.3	− 1.6
May 3	3,097	21.8	3,240	17.7					− 1.8
May 4	1,261	8.9			(a)	(a)			
May 5	1,842	13.2							
May 6	2,263	16.1	870	14.0					+ .1
May 7	2,040	13.1							
May 8	2,007	10.5	760	10.1					− 1.6
May 9	1,891	10.9	850	11.6					− 2.7
May 10	3,057	21.1	1,000	10.9					+ 8.2
May 11	2,700	18.6							
May 12	2,610	16.1	1,180	11.3					+ 2.8
May 13	3,297	22.5	1,500	7.4					+12.6
May 14	3,522	25.4	930	7.6					+16.8
May 15	3,479	26.1	1,120	11.4					+12.7
May 16	3,466	20.5	1,390	6.2					+12.3
May 17	2,932	19.21	870						
May 18	2,580	16.03	900	4.4					+ 9.6
May 19	3,129	21.6							
May 20	3,103	21.2	2,210	16.8					+ 2.4
May 21	3,170	22.4	2,250	10.9					+ 9.5
May 22	3,219	19.1	1,470	11.4					+ 5.7
May 23	3,331	19.4	2,480	13.8					+ 3.6
May 24	2,761	17.2	1,500	10.3					+ 4.9
May 25	3,760	24.7	1,460	9.2					+13.6
May 26	4,228	26.7	2,770	11.0					+13.7
May 27	3,284	22.3	2,060	12.2					+ 8.1
May 28	3,640	24.6	1,880	12.1					+10.5
May 29	3,715	23.0	1,310	12.9					+ 8.1
May 30	3,470	23.5	1,590	14.4					+ 7.1

[a] Resection.

The patients had been kept on a soft diet containing from 1,000 to 1,700 calories, previous to the nitrogen determinations, and were losing from 12 to 20 gm. of nitrogen per day. They were placed on the regular hospital diet, supplemented by extra feedings of eggs and milk. No attempt was made to keep them at a constant level of feeding since the increased accuracy of the figures would not have justified the loss of food to the patient.

Charts LXVIII, LXIX, and LXX represent the relation of the nitrogen balance to the food intake. The broken line represents nitrogen gain or loss in grams, and the unbroken line represents the food intake in calories. Nitrogen equilibrium is placed at 3,000 calories. With the scale used (5 gm. of nitrogen and 500 calories each represented by the same unit), the curves run quite parallel. Wherever the unbroken line is above the broken line, more than 3,000 calories would have been required to keep the patient in equilibrium, and wherever the broken line is above the unbroken line, less than 3,000 calories would have maintained equilibrium. The distance between the lines is a rough measure of the amount above or below 3,000 calories required to maintain equilibrium.

It will be noticed that in the acute stage of the disease with a high temperature, from 3,000 to 3,300 calories were needed to maintain equilibrium. It will also be noted that some patients lost weight although they had a constantly positive nitrogen balance. This was undoubtedly due to the fact that the nitrogen of the feces was disregarded. Probably from 3,300 to 3,500 calories would have been needed to maintain body weight.

Since these patients might lose in one day of low feeding as much as could be regained in several days of high feeding, it was important that a close watch be kept on their food intake. It was recommended that they be placed as early

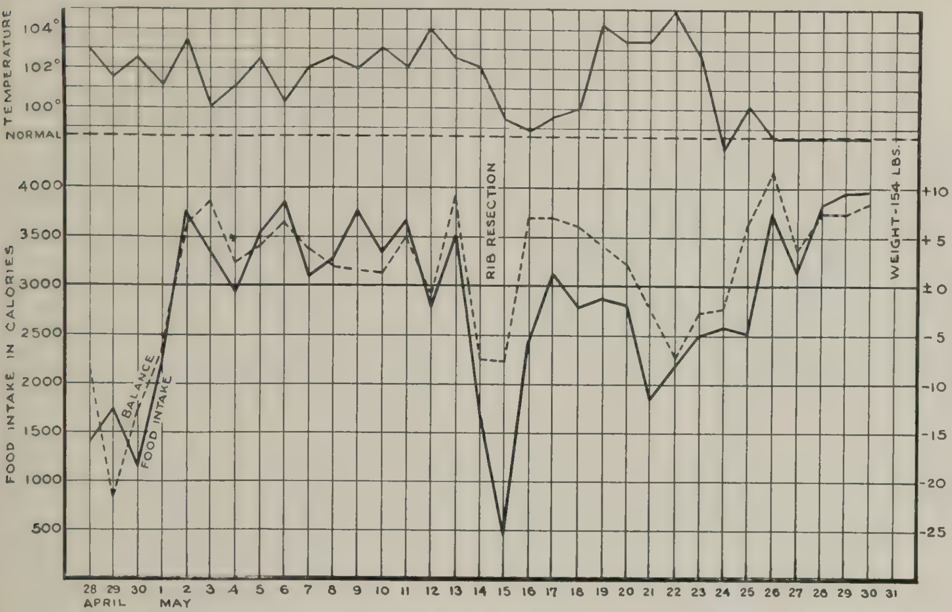

CHART LXVIII.—Nitrogen conservation. Case 1.

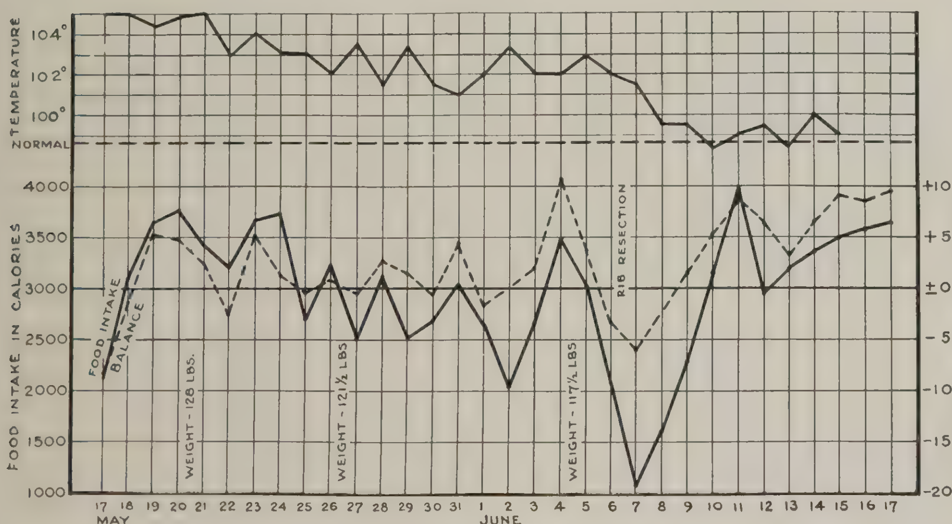

CHART LXIX.—Nitrogen conservation. Case II.

as possible on a standardized diet containing from 3,300 to 3,500 calories, and kept on this until they reached their normal weight. The fuel value of any food remaining uneaten was estimated, and extra feedings of eggs, milk, etc., were given to make up the total. While the patient was very ill, lactose drinks were used and, when necessary, glucose was given by rectum or intravenously. The patient was weighed on admission and at least once a week thereafter.

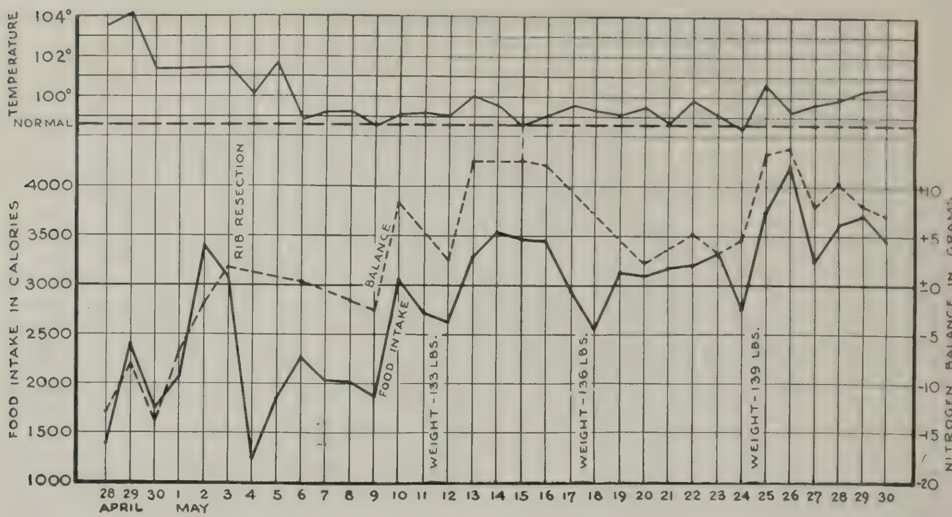

CHART LXX.—Nitrogen conservation. Case III.

Tables 55 to 61 show a few sample diets used at Camp Lee. The cost of this diet was estimated by the mess officer of the hospital to be 87 cents a day.

TABLE 55.—*High calorie diet during the acute febrile stage in Case I, May 1–2, 1918.*

	Quantity in grams or cubic centimeters.	Proteins.	Fats.	Carbohydrates.		Quantity in grams or cubic centimeters.	Proteins.	Fats.	Carbohydrates.
Milk	1,680	55.0	67.0	84.0	Cream tomato soup	150	3.0	1.6	6.0
Sugar	36	....	....	36.0	Custard (2 cups)	....	10.2	15.4	64.0
Eggs (4)	....	26.4	24.0	....	Rice	60	2.4	.8	21.2
Toast	135	15.5	2.2	82.6	Cocoa	180	7.0	8.3	11.3
Butter	32	....	27.2	....	Orange (one-half)	....	.3	.1	4.6
Meat, scraped	80	16.7	8.5	....	Oatmeal	150	4.2	.7	17.2
Puree peas (2 tablespoons)	....	2.5	.1	3.1	Apple sauce	60	.1	.5	24.8
Potato	50	1.2	....	10.4					
Ice cream	100	5.2	10.1	17.7	Calories, 3,732; nitrogen, 23.95	....	149.7	166.5	382.9

TABLE 56.—*High calorie diet during the acute febrile stage in Case I, May 2–3, 1918.*

	Quantity in grams or cubic centimeters.	Proteins.	Fats.	Carbohydrates.		Quantity in grams or cubic centimeters.	Proteins.	Fats.	Carbohydrates.
Milk	510	16.8	20.4	25.5	Vegetable soup with noodles	240	7.3	0.1	2.8
Eggs (5)	....	33.0	30.0	....	Macaroni with cheese	100	5.0	4.5	15.8
Sugar	18	....	....	18.0	Farina pudding	100	3.3	3.4	17.9
Chicken	80	16.0	8.8	....	Apricots, stewed	75	.6	....	12.6
Baked potato	86	1.7	.1	15.8	Junket	100	3.3	.4	7.0
Butter	28	....	23.8	....	Cocoa	300	12.1	14.9	18.8
Toast	225	25.9	3.6	137.7	Grapefruit	150	1.2	.3	12.2
Asparagus, creamed	100	2.5	5.7	4.6	Oatmeal	210	5.9	1.0	24.1
Spinach, puree	100	3.6	7.1	4.5					
Chocolate pudding	120	5.1	7.7	21.0					
Cream	30	.7	5.5	1.3	Calories, 3,322; nitrogen, 23.2	....	145.0	137.5	353.5

TABLE 57.—*High calorie diet during the acute febrile stage in Case I, May 9–10, 1918.*

	Quantity in grams or cubic centimeters.	Proteins.	Fats.	Carbohydrates.		Quantity in grams or cubic centimeters.	Proteins.	Fats.	Carbohydrates.
Milk	810	26.7	32.4	40.5	Apple sauce	134	.3	1.1	49.8
Eggs (3)	....	19.8	18.0	....	Pudding, bread custard	102	6.5	5.0	25.8
Sugar	25	....	....	25.0	Lemon (1)	1	1.0	.7	8.5
Chopped beef	80	22.1	6.2	....	Cocoa	570	20.9	25.8	32.5
Potato	70	1.7	.1	14.6	Hominy	200	4.4	.4	35.4
Puree peas	70	9.8	4.0	26.8	Prunes	110	.6	.1	24.5
Toast	143	16.4	2.3	87.5					
Butter	20	....	17.0	....	Calories, 3,347; nitrogen,				
Custard	132	5.5	8.3	34.3	21.71	....	135.7	121.4	405.4

TABLE 58.—*High calorie diet during the acute febrile stage in Case I, May 10–11, 1918.*

	Quantity in grams or cubic centimeters.	Proteins.	Fats.	Carbohydrates.		Quantity in grams or cubic centimeters.	Proteins.	Fats.	Carbohydrates.
Milk	1,050	34.6	42.0	52.5	Fish	70	14.0	1.7	....
Eggs (6)	....	39.6	36.0	....	Chocolate pudding	110	5.0	7.9	27.8
Lemon (1)	....	1.0	.7	8.5	Ice cream	130	6.8	13.1	23.0
Sugar	28	....	....	28.0	Vegetable soup	420	10.5	....	18.0
Orange juice	60	.5	.1	7.0	Cocoa	120	5.0	6.3	8.0
Oatmeal	200	5.6	1.0	23.0	Custard	90	3.8	5.7	23.4
Toast	255	29.3	4.1	158.1	Peach	40	.3	....	4.3
Butter	30	....	25.5	....					
Potato	82	2.0	.1	17.1	Calories, 3,662; nitrogen,				
Spinach	80	1.7	3.3	2.1	25.55	....	159.7	147.5	398.8

TABLE 59.—*Diet on day of rib resection in Case I, May 13–14, 1918.*

	Quantity in grams or cubic centimeters.	Proteins.	Fats.	Carbohydrates.		Quantity in grams or cubic centimeters.	Proteins.	Fats.	Carbohydrates.
Lemon albumen	....	3.9	0.6	12.5	Cornflakes	30	4.0	.4	22.3
Milk	1,140	37.6	45.6	57.0	Sugar	28	....	....	28.0
Orange	175	1.4	.3	20.3					
Cocoa	300	12.0	15.0	19.0	Calories, 1,679; nitrogen,				
Cream of tomato soup	120	3.0	9.4	6.4	11.2	....	68.9	71.3	177.5
Vegetable soup	240	7.0	....	12.0					

TABLE 60.—*Diet following operation in Case I, May 14–15, 1918.*

	Quantity in grams or cubic centimeters.	Proteins.	Fats.	Carbohydrates.		Quantity in grams or cubic centimeters.	Proteins.	Fats.	Carbohydrates.
Eggnog	150	8.4	8.8	6.0	Whiskey (calories 105)	30	....	....	....
Oatmeal	200	5.6	1.0	23.0					
Milk	190	6.3	7.6	9.5	Calories, 464; nitrogen,				
Sugar	15	....	....	15.0	3.41	....	20.3	17.4	53.5

TABLE 61.—*Convalescent high calorie diet in Case I, May 25–26, 1918.*

	Quantity in grams or cubic centimeters.	Proteins.	Fats.	Carbohydrates.
Milk	2,060	68.0	82.4	103.0
Eggnog	700	33.0	36.0	30.0
Meat	30	6.7	8.6	....
Potato	65	1.6	....	13.6
String beans	60	.7	....	2.3
Bread	100	9.2	1.3	53.1
Toast	57	6.5	.9	34.9
Butter	20	....	17.0	....
Rice pudding	95	6.2	4.7	23.0
Thin cream	60	1.5	6.0	2.7
Cream tomato soup	350	8.4	26.2	17.8

	Quantity in grams or cubic centimeters.	Proteins.	Fats.	Carbohydrates.
Creamed peas	72	4.3	5.4	9.6
Stewed peaches	83	1.6	1.1	11.3
Junket	62	2.1	2.5	11.1
Cornflakes	15	.1	....	6.0
Sugar	15	....	....	15.0
Bacon	29	5.6	14.5	....
Grapefruit	180	1.1	.2	11.6
Calories, 3,734; nitrogen, 25.06		156.6	206.8	285.2

The feeding of the patients during the acute stage of the illness required the persistent efforts of the nursing staff. Feeding was accomplished after operation with less difficulty and the average increase in weight was more evident. This was due of course both to the increasing appetites of the patients

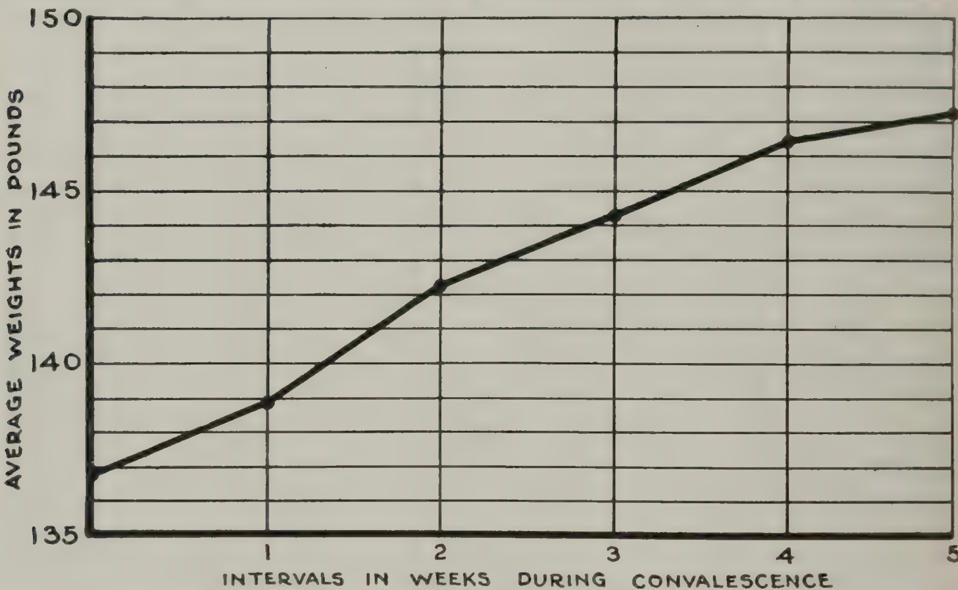

CHART LXXI.—Average postoperative increase in weight of 71 patients on a high calorie diet.

and to the lowered metabolic rates during defervescence. When, following operation, the patients did not gain on a high calorie diet, careful examination usually revealed undrained pleural pus pockets. The average weights of 71 patients on a diet of 3,000 to 3,500 calories have been charted for a period of five weeks after operation.

ROUTINE MEDICAL CARE.

During the acute febrile period of these streptococcus infections medicinal remedies were only of symptomatic value. Digitalis was used in some military hospitals with but little benefit. When it was employed, 4 or 5 c. c. of standardized tincture were given on the second or third day of the pneumonia. Occasionally, smaller doses were given for several days. It must be remem-

bered, however, that the majority of the patients were young, robust men and that there were few who had chronic cardiac disease. Death was usually due to extensive infection of the lungs or the serous cavities and not primarily to cardiac failure. Atropine was valuable at times in the treatment of edema of the lungs. The administration of the drug was continued until the pupils were slightly dilated. When the edema was fully developed, and the patient was cyanotic, atropine was valueless. The tolerance for atropine was apparently increased during the pneumonia, as larger doses were needed than are ordinarily required to obtain the physiological effect in the average patient. Codeine and morphine were invaluable for the pain and delirium.

During the winter months the majority of the cases of bronchopneumonia were not improved by outdoor treatment. Fresh air at ordinary room temperature was most beneficial. As they lessened the delirium, temporarily lowered the temperature, and stimulated the circulation, tepid sponge baths were employed during the height of the fever. In anemic patients transfusions of large quantities of blood (1,000 c. c.) were valuable during the third and fourth weeks of the disease. No benefit was observed from the use of streptococcus serum and vaccines employed as curative measures.

CONVALESCENT CARE AND TREATMENT.

Medical care during convalescence after operation was confined to dietary measures and to the treatment of the sequelæ of the infection. When possible, high calorie diets were continued for several weeks after the empyema wounds were healed. The patients who were kept on diets of 3,000 to 3,500 calories were not only in better physical condition but the diets served as a therapeutic test regarding the permanency of the wound closure. When the patients did not gain weight on this diet, pus was found in the closed sinus or other pleural foci of infection were discovered. A few were found to be tuberculous.

The most important part of the medical observation during convalescence was the repeated examination of the chest. In the majority of instances all pleural pus pockets were discovered and drained soon after the pneumonia had subsided. However, in 4 to 5 per cent of the patients, purulent pleural pockets were found from the third to the sixth month of convalescence. The symptoms of these were persistent temperature and tachycardia and the patients were always under weight. Few of these patients gained on forced feeding. The examination consisted in careful physical inspection, repeated Roentgen-ray observations, and aspiration of the thorax when there was any question of the pathological condition.

There were few other sequelæ. Albuminuria persisted during convalescence in about 1 per cent of the patients, but it was rarely observed after an interval of two years. It was most common among patients in whom the empyema had not been completely drained. Tachycardia was observed in about 6 per cent of the patients convalescent from streptococcus infections. About 5 per cent of these patients had undiscovered septic foci in the pleura or lung, but no cause was found for the remaining 1 per cent. The tachycardia was often associated with cyanosis, dyspnea, and cardiac pain on exertion. Frequently these symptoms cleared up after graduated exercises. In other cases where the tachycardia was permanent, it was evidently due to a chronic myocarditis and cardiac insufficiency.

Graduated exercises were begun soon after operation for the empyema. Ordinarily, the patients were ambulatory within one or two weeks after the operation. At first the exercises consisted of light work around the wards, then outside duties and exercises were added as soon as the physical condition of the patients permitted. After the wounds were healed marches and the routine exercises described by the Army manuals were prescribed under careful medical supervision.

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CHAPTER VII.

THE SURGICAL TREATMENT OF EMPYEMA IN THE ACUTE AND CHRONIC STAGES.

In any case of empyema the treatment should be aimed at the saving of life, the prevention of chronicity, and the restoration to conditions that are as nearly normal as possible. In order to accomplish these purposes certain principles have been worked out which are based on fundamental considerations of the physiology and pathology involved. These principles are, essentially, the avoidance of an open pneumothorax during the period in which a severe pneumonia is likely to be present, the maintenance of the nutrition of the patient, and attempts at the early sterilization and obliteration of the cavity. After an empyema has become definitely chronic, with a discharging sinus of a duration of several months, problems arise in its treatment which are different from those affecting an acute case. This question, as well as the treatment of the surgical complications of empyema, will be considered later on.

In most of the camps in the United States during the early part of the influenza epidemic of 1917–18, practically all cases of empyema were treated by the then conventional method of operation and open drainage as soon as diagnosis was made of the presence of infected fluid in either one or both of the pleural cavities. The associated high mortality strongly suggested that the current ideas of treatment needed modification. Answers to a questionnaire[1] which was sent out to the various camps by the Surgeon General were compiled in March, 1918, and an average mortality of 30.2 per cent was reported in the cases diagnosed as empyema. In some of the camps, however, the mortality was so high that it approached 90 per cent in the operated cases. Observations of the Empyema Commission at Camp Lee[2] led to a conviction that many patients who were operated on died as a result of the additional burden of asphyxia incidental to the creation of an open pneumothorax during the period of acute pneumonia. Therefore, instead of creating an immediate open drainage as soon as a diagnosis was made of the presence of an infected pleural fluid, such cases were treated first by preliminary aspiration and later were subjected to open drainage. An immediate drop from 40 per cent to 4.3 per cent occurred in the mortality following the institution of this method. At some of the other camps, also, a similar procedure had been instituted, with results that were more favorable than those obtained by the conventional methods of treatment. At the same time, and in view of the fact that reports from the hospitals in France indicated that the chest could be opened as widely as desired for the purpose of removing foreign bodies, widespread consideration was given the importance of the factor of open pneumothorax in the early stages of an empyema. Because of the uncertainty and confusion incident to the important bearing of the open pneumothorax, two members of the Empyema Commission were detailed to take up the whole question experimentally. The result of this experimental work, published at that time, was in part as follows:[3]

THE MECHANICS OF THE THORAX IN RELATION TO EARLY DRAINAGE.

The process of inspiration consists essentially of a sudden enlargement of the thorax which results in a rush of air down the trachea into the lungs. The

antithesis of this process is the act of expiration, a sudden diminution of the volume of the thorax which forces air out of the lungs again. It is evident that the essential condition which must be created by enlargement of the thorax in order to accomplish the rush of air down the trachea to the lungs is a diminution of pressure within the lungs. Under ordinary conditions the pressure within the pleural space is less than atmospheric pressure. Donders,[4] who was the first to measure these pressures in the human, found values of -9 mm. of mercury at the end of inspiration and of -7.5 mm. of mercury at the end of expiration. If this pressure should be positive (equal to or more than atmospheric pressure) during the act of inspiration, obviously there would be no rush of air down the trachea into the lung.

For these reasons it is of the greatest importance to consider not only how the intrapleural tension may be altered but the effects of such changes as well. The most striking way in which to demonstrate the effects of suddenly altering intrapleural pressure is to create an open pneumothorax—an effect which always follows the creation of an early, open drainage of a case of empyema. The ordinary conceptions of the effects of an open pneumothorax have been based upon the faulty reasoning that any opening in the chest wall, no matter of what size, would result immediately in the establishment of atmospheric pressure within the pleural cavity on the side of the opening. These conceptions carry with them the idea that the mediastinum acts as a more or less rigid partition between the two pleural cavities and that when an opening is made into one pleural cavity the lung on that side becomes collapsed and respiration is maintained by the other lung. These ideas have become so deeply ingrained that all through the literature one finds references to the "collapsed" lung on one hand and the "sound" or "healthy" lung on the other. For example, Garré[5] in a series of diagrams to illustrate the conditions in open pneumothorax, shows the mediastinum as a straight line, in cases in which the opening is small, with one lung collapsed and retracted and the other lung (on the unopened side) of normal size and apparently unaffected. In cases with a large opening essentially the same condition is shown except that there is a slight bulging of the mediastinum away from and toward the opening in inspiration and expiration respectively. Likewise, the lung on the side of the opening is shown as collapsed and contracted into a small mass about the hilus, whereas the opposite lung appears to be relatively unaffected. L. Mayer[6] summarizes from the literature the prevalent views on the changes produced by an open pneumothorax:

On the healthy side the modifications due to the pneumothorax with a small opening should adjust themselves by a deviation of the mediastinal pleura, the two surfaces of which are no longer submitted to conditions of identical equilibrium; on inspiration the lowering of the intrapulmonary pressure of -7 mm. mercury not manifesting itself on the fistula side, the mediastinal pleura should become curved toward the healthy side and narrow the expansion of the other lung; the inverse should be produced at expiration. In reality these theoretical differences are minimal and are scarcely established by experimentation. If, on the contrary, the pleural opening is widely gaping the atmospheric air enters and goes out freely at each respiratory movement and the lung of this side will not be called upon at all to become distended. At each inspiration the pressure of the two sides of the mediastinal pleura will be different; on the healthy side negative pressure of 7 mm. Hg., on the other side atmospheric pressure, with aspiration of the mediastinum toward the healthy side, toward which it ought to be markedly convex. In moderate and light expiration the pressure on the two sides remains equal; but if a forced or sudden expiration supervenes the pressure is raised in the normal lung while it remains constant on the incised side, giving a convexity of the mediastinum on the side of the pneumothorax.

Direct experimental observations, which were made by Graham and Bell[3] while members of the Empyema Commission of the United States Army,[2] show that these conceptions are erroneous, in that, in the normal thorax the mediastinal structures offer so little resistance to changes of pressure that any change in one pleural cavity affects the other to practically the same extent.

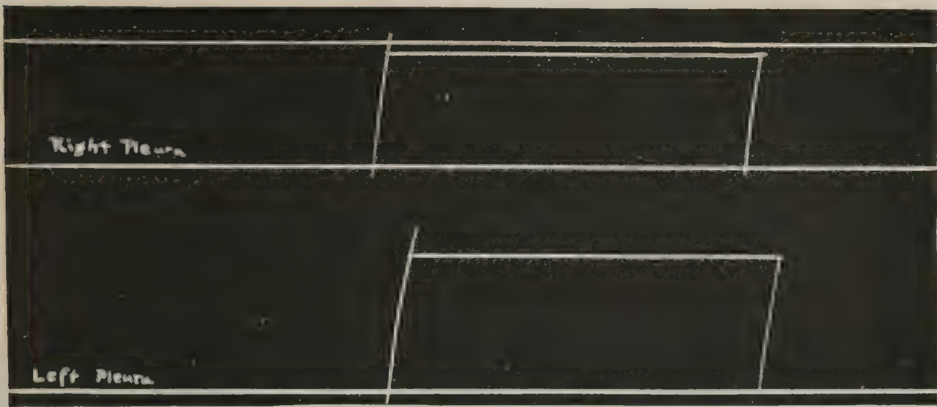

FIG. 56.—Tracing showing that when the left pleural cavity of a fresh adult human cadaver is inflated with air at a pressure of 10 cm. of water the right pleural cavity registers a pressure of 9 cm. The top line is a record of a pressure of 10 cm. made with the tambour attached to the right pleural cavity. Calibration showed that the actual pressure was 9 cm. of water.

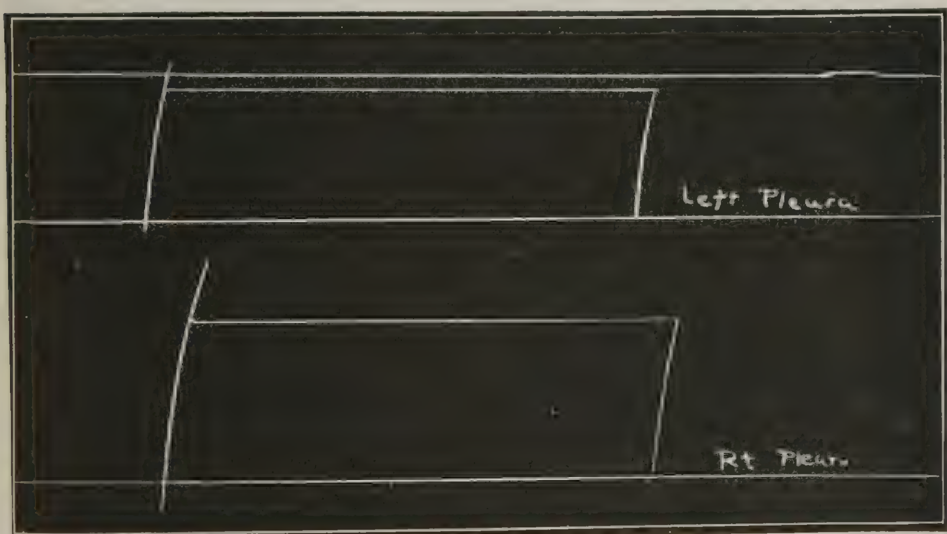

FIG. 57.—A tracing similar to that shown in Fig. 56 with the right pleural cavity inflated. Calibration showed that in this case also there was difference in pressure of only 1 cm. of water (about 0.8 cm. of mercury).

There is, therefore, practically an equilibrium of pressure throughout the normal chest and from the standpoint of pressure relationships the normal thorax can be considered as one cavity instead of two. When one pleural cavity is inflated with air at a known pressure of 10 cm. of water the pressure in the other pleural cavity is found to vary from 9 to 9.5 cm. of water. In other words, even with so slight a pressure as 10 cm. of water, the resistance of the

mediastinum is equivalent to the pressure exerted by only 0.5 to 1 cm. of water. Reduced to terms of mercury this value is equivalent to only about 0.4 mm. or 0.8 mm., respectively, and is, therefore, negligible. One lung, then, does not collapse to an appreciable extent more than the other, and the commonly supposed condition of collapse of one lung with maintenance of respiration by the other does not occur. Moreover, the pressure even in the opened pleural cavity does not come into equilibrium with that of the atmosphere until after death, owing to the constantly changing size of the thorax as a result of the respiratory movements. In this respect it is difficult for some to recognize the difference between a structure with fixed walls and one, like the thorax, which has moving walls. During expiration, the intrapleural pressure in open pneumothorax actually exceeds that of the atmosphere, but both by theory and by actual determination the intrapleural pressure becomes less than atmospheric pressure on inspiration. The results were the same in the human and in the dog.

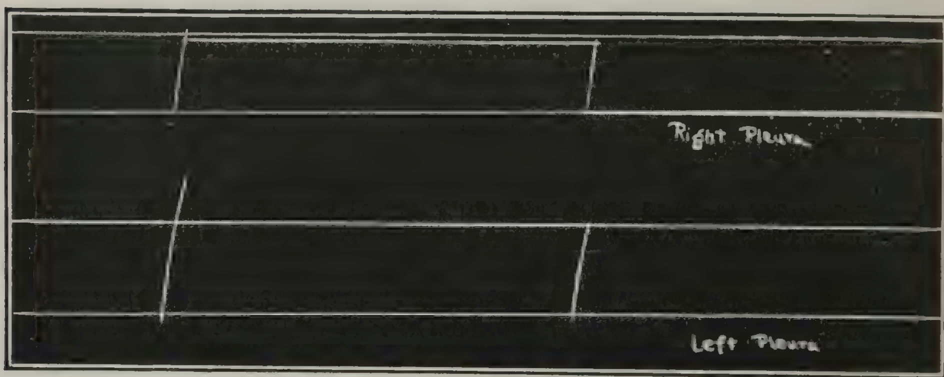

FIG. 58.—Tracing made in the same way as is Fig. 56 with a recently killed dog, which shows that the dog is strictly comparable with the human, since here, also, the difference in pressure between the two pleural cavities amounted to only 1 cm. of water.

A more direct method of determining whether the lungs are equally compressed consists of measuring their relative densities when one pleural cavity is inflated with air at a known pressure. If the pressure relationships in both pleural cavities are affected about equally by altering the pressure in one, then both lungs should be about equally compressed and should show almost equal relative densities. The results obtained on five dogs bear out this idea.

	Density of lungs.	
	Left.	Right.
No. 1. Right pleural cavity inflated with air to a pressure equal to that of 10 cm. of water	0.74	0.74
No. 2. Left pleural cavity inflated	.73	.69
No. 3. Left pleural cavity inflated	.70	.72
No. 4. Control, not inflated	.52	.48
No. 5. Control, not inflated	.43	.51

By showing an equal amount of compression of both lungs when only one pleural cavity is inflated these results lend striking support to the conclusion drawn from the other experiments: in the normal thorax, alterations of pressure in one pleural cavity are accompanied by practically the same changes in the other pleural cavity.

If, in the living dog, an open pneumothorax is created on one side, a characteristic response occurs which is manifested not only by a change of intrapleural pressure on the opened side but also by a change of the same kind and of practically the same degree on the unopened side. Briefly, the phenomena which occur are as follows: Immediately after making the opening there is a simultaneous change of pressure in the two pleural cavities from an entirely minus or negative (less than atmospheric) phase to one which oscillates between a positive or plus (more than atmospheric) and a minus phase. The size of the opening, as will be shown later, materially influences the extent of the change of pressure. The respirations are sometimes slowed and increased in amplitude, but at other times they are accelerated. As the intrapleural pressure diminishes, the intratracheal pressure tends to become constant, as would be expected, since the intratracheal pressure is a rough index of the amount of air passing down the trachea. Immediately upon closure of the opening, there is a simultaneous response in both pleural cavities with a more complete restoration of negative pressure, a diminution of the amplitude of the respiratory movements and oscillations again of negative and positive intratracheal pressure on inspiration and expiration. These changes can be better understood by reference to the accompanying reproduction of a tracing.

The extreme mobility of the human mediastinum in the absence of adhesions has been shown in X-ray studies on pneumothorax by Stivelman and Rosenblatt,[7] and more recently by Stivelman, Hennell, and Golembe.[8] The work of these observers tends to confirm the truth of the general idea, developed in the experimental work under discussion, of the practical equilibrium of pressure throughout the normal thorax. Murphy,[9] recognizing the dangerous tendency of the mediastinum to "flutter" in an open pneumothorax, recommended traction on the lung in an attempt to immobilize the mediastinum.

West[10] reached a conclusion which seems to agree rather closely with the idea developed by Graham and Bell. He apparently made no actual measurements of the pressures, but had he done so it would seem that the results would probably have been in exact agreement with these two members of the Empyema Commission. He states:

> When one pleural cavity is laid freely open to the air there will then be atmospheric pressure on both sides of the visceral pleura; the elasticity of the lungs will come into play, and the exposed lung will collapse. But this is not all, for the alterations in pressure do not affect the one lung only; the mediastinum being not a fixed partition, but a movable one, the elasticity of the opposite lung also comes into play; with the result that the mediastinum and the organs therein are drawn over to the sound side. Thus it follows that the opening of one pleura not only satisfies the elasticity of the one lung, but goes a long way to satisfy the elasticity of the other. If, for example, the pressures be reduced to figures, and we assume for the sake of illustration that in a healthy man the total elastic contractility of the two lungs together amounts to 50, the opening of one pleura may satisfy this elasticity to the extent of 40, leaving only 10 for the unsatisfied elasticity of the opposite lung. Thus, in pneumothorax, which is the corresponding pathological condition, if the lungs are healthy and their elasticity at the maximum, the total respiratory capacity will be suddenly reduced by four-fifths.

Lenhart[11] obtained results in experiments on rabbits which he said tended to confirm the results of the experiments of the members of the Empyema Commission.

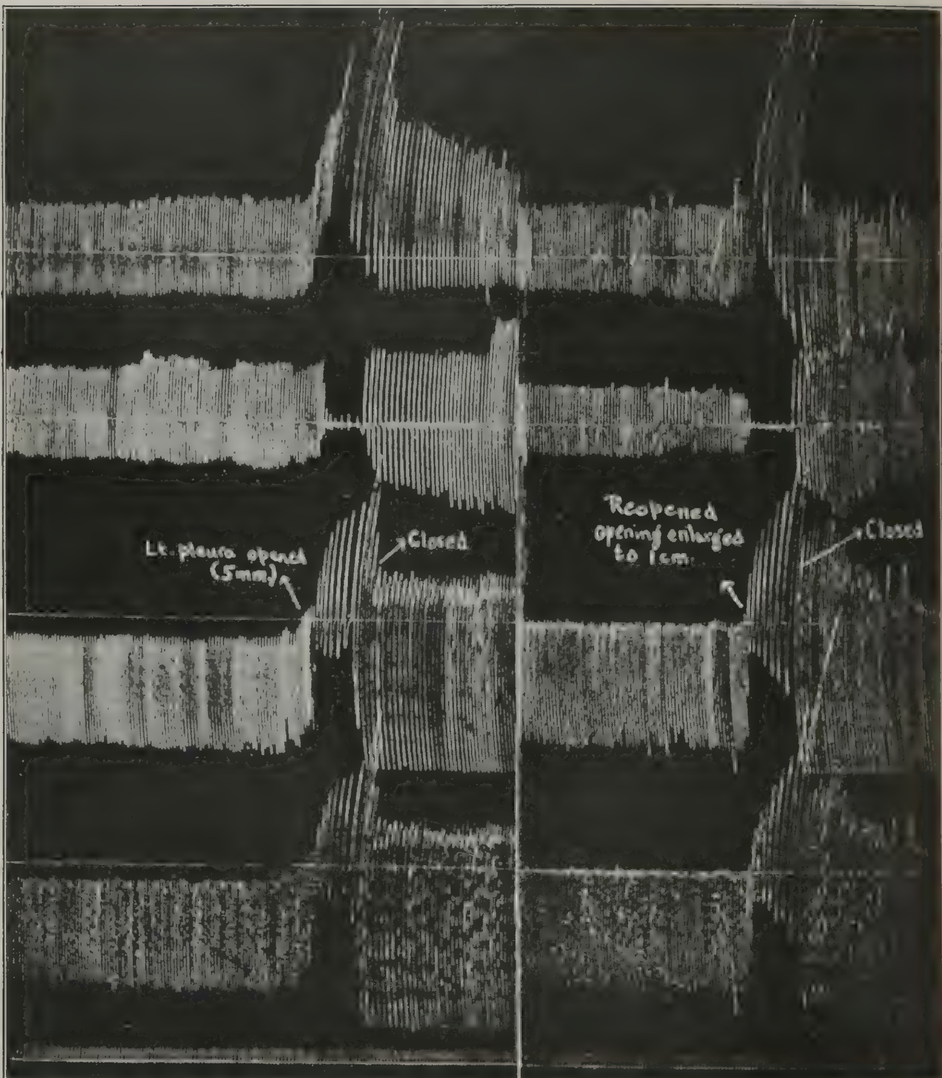

FIG. 59.—A tracing made on the living dog under ether anesthesia to show the nature of the reaction to an open pneumothorax with a moderate opening, as indicated in the changes in the respiratory movements, in the tracheal pressure and in the pressures in both pleural cavities. The uppermost tracing represents the respiratory movements, the next the tracheal pressure, the third the left pleural pressure, and the fourth one the right pleural pressure. The lowest line indicates the time in seconds. The base lines were drawn at atmospheric pressure. The interval represents a duration of six minutes. Immediately after making the opening there is a simultaneous change of pressure in the pleural cavities from an entirely negative phase to one which is mostly positive. The respirations are slowed, but are increased in amplitude. Because the intrapleural pressure is largely positive, practically no air enters the trachea and the intratracheal pressure tends to be at equilibrium with atmospheric pressure. Immediately upon closure of the opening there is a simultaneous response in both pleural cavities, with restoration of negative pressure to a large extent, diminution of the amplitude of the respiratory movements and oscillations again of positive and negative intratracheal pressure, with inspiration and expiration. After an interval of six minutes, during which time the air in the pleural cavities has probably been absorbed, the intrapleural pressure has again become entirely negative.

It should be stated here that often, in small punctured wounds of the chest, even where the lung has been injured, the air does not enter the pleural cavity to create a pneumothorax, but instead it finds its way into the soft tissues of the chest wall. This phenomenon is frequently seen in association with fractured ribs. As an explanation of it West[12] suggested that the cohesion between the two layers of pleura is so great that a considerable force is necessary to separate them. MacEwen[13] has also adopted this explanation.

The older conceptions of the immediate establishment of atmospheric pressure within a pleural space, as soon as an open pneumothorax is created, fail to take into consideration the fact that the thorax, instead of being a rigid box, has movable walls, which, by changing the size of the contained space, likewise change the pressure within it. If the older conceptions were correct, then a small opening into the chest would have the same consequences as a large one, because in each case "collapse" of the corresponding lung would occur. It would follow from this that, in a normal chest, a unilateral, open pneumothorax ought never to be fatal, regardless of how large the opening might be, since the worst possible consequence would be the "collapse" of one lung. Similarly, also, with the same line of reasoning, a bilateral, open pneumothorax should always be promptly fatal. Experiences, however, both experimental and in the World War, which controvert these two conclusions, have been many. A dog, for example, will live indefinitely with a bilateral open pneumothorax if the openings are not too large. It is also easy to demonstrate experimentally that a definitely quantitative relationship exists, in any individual with a normal thorax, between the size of the opening in an open pneumothorax and the danger of death, because the really important factor is the amount of air which enters the chest from the outside with each inspiration.

A mathematical expression has been devised by which it is possible to approximate, in a given case, the maximum opening in the chest wall which is compatible with life. This expression is as follows:

$$X = \frac{V - \frac{R_1}{R_2}T}{\frac{R_1}{R_2}T} aC$$

In this expression V is the "vital capacity", R_1 is the rate of respiration before the opening is made, R_2 is the rate of respiration after the opening is made, T is the tidal air (approximately 500 c. c.), a is a factor less than 1 (assumed to be about 0.8), and C is the area of the glottis (about 2.25 sq. cm.). By substituting numerical values the determination of X becomes a problem of simple arithmetic. The average vital capacity V and the "tidal air" T are given by Howell[14] as 3,700 c. c. and 500 c. c., respectively. The normal rate of respiration R_1 during complete rest is about 15 per minute, and the maximum rate R_2 for the greatest possible depth of respiration is about 60 per minute.

$\frac{R_1}{R_2}T$ then equals 125 and

$$X = \frac{3700 - 125}{125} aC = 28.6\ aC$$

$$X = 28.6\ (0.8 \times 2.25) = 51.5 \text{ sq. cm.}$$

In other words, in an individual with an average vital capacity (3,700 c. c.), an opening of about 51.5 sq. cm. (8.1 sq. in.) is the largest for which compensation can be made if the mediastinum has a normal mobility. It is obvious, however, that when the factor V ("vital capacity") is increased the value of X will also increase. Consequently those individuals whose vital capacity is greater than 3,700 c. c. will be able to withstand openings of greater areas than 51.5 sq. cm. In this connection it is noteworthy that Peabody and Wentworth [15] have shown that the average vital capacity for men is considerably higher than that of the general average of both men and women. The average value based on their observations on men is 4,633 c. c. If this value is substituted for V in the given equation, the value for X is found to be 64.8 sq. cm. (10 sq. in.). The maximum opening, therefore, for which the average man can compensate is about 64.8 sq. cm. In the exceptionally large man of athletic build, as for example in the case of the man mentioned by Peabody and Wentworth who had a vital capacity of 7,180 c. c., a relatively enormous opening in the chest wall can be compensated for.

In such a case, for instance, the value of X in the equation would be 101.3 sq. cm., or 15.6 sq. in. Practically, the opening must be somewhat smaller, as the extra work performed by the muscles of respiration to establish compensation increases the amount of air required. The presence of toxemia, infection, or any other cause which increases the level of metabolism will decrease the safety limits of the maximum size of the opening, as will also any condition reducing the available breathing space of the lung. The use of general anesthesia will probably also act in the same way. It should be borne in mind that the value of X represents the approximate maximum opening compatible with life only so long as the respiratory muscles can maintain a maximum respiratory movement, and, in addition, that it is only an approximation because of variability in different individuals of some of the other factors, as for example, C. It is striking, however, that, owing to the negligible resistance offered by the mediastinum, it makes very little difference whether there is a unilateral or a bilateral open pneumothorax, provided that the combined areas of the openings in the bilateral case do not exceed the area of the unilateral opening. This fact clearly controverts the former conception of the necessary "collapse" of a lung after the creation of a pneumothorax. If in a living dog an opening into the chest be made in a suitable place for inspection, as, for example, in about the 5th interspace in the mid-axillary line, the expansion and contraction of the lung can be observed to occur with each act of respiration.

The reasons for this quantitative relationship are to be found in the following facts: (1) It is possible to maintain life as long as the lungs can inspire the tidal air, which normally is from 300 c. c. to 500 c. c.; (2) a considerable encroachment on the volume of the two lungs can be made before a stage is reached at which it is no longer possible for the lungs to obtain the tidal air; and (3) in the compensatory reaction, by an increase in the amplitude of the respiratory movements, the thorax is so enlarged that actually more air may enter through the pneumothorax opening without encroaching to the same extent on the tidal air than would be the case if the thorax were not enlarged.

It must be particularly emphasized, however, that this consideration of the practically negligible resistance of the mediastinum, with the associated equality of pressure throughout the thorax, refers only to the normal thorax. Obviously, a thickening of the mediastinum by old inflammation and the

presence of strong adhesions will change the conditions and will permit the development of a considerably greater pressure on one side than on the other.

An open pneumothorax induces other harmful effects than those on respiration. These have been summarized by Sauerbruch [16] as loss of heat, danger of infection, and disturbances of the circulation. Sauerbruch has made the important observation that the loss of heat from an open pneumothorax may exceed that which follows an extensive laparotomy incision with eventration of the intestine; and owing to the changed pressure relationships, a stasis in the venous system occurs which is shown by an actual increase of pressure in the femoral vein.

In the case of a closed pneumothorax conditions very different from those in an open pneumothorax are present. In the description of the characteristic changes produced by making a free opening into the pleural cavity it was stated that the closure of the opening resulted in a sudden restoration of negative pleural pressure and a prompt relief from dyspnea. Obviously, after making the closure, air is retained in the pleural cavity, so that the very striking difference in the phenomena observed must be due merely to the fact that an open pneumothorax has been converted into a closed one. Although air is absorbed from the pleural cavity, it disappears only slowly; and the sudden benefit noted by the closure of the opening can not be attributed to the immediate disappearance of the air. Apparently the explanation of the relative harmlessness of a closed in comparison with an open pneumothorax lies in the fact that the ability to compensate for interference with aeration of the lungs is limited. In a closed pneumothorax, no matter how much air is contained in a pleural cavity no additional air can enter.

In such a case, in animal experimentation, it is necessary for the animal to increase his respiratory effort only sufficiently to create that negative pressure which would allow him to breathe the requisite amount of air to maintain oxygenation of his blood. Under conditions of rest this amount is equivalent to the tidal air, which in the human is a relatively small fraction of the vital capacity (from about one-seventh to one-twelfth). A fatal asphyxia, therefore, should not occur until so large a proportion of the lung capacity has been replaced by air in the pleural cavity that the animal's vital capacity equals his tidal air, provided that the animal is at rest, and his ability to compensate by increasing his respiratory effort is good and that there is no extraordinary demand for air, such as might arise from toxemias. When an open pneumothorax is converted into a closed one, particularly if the closure is made at the end of expiration, the amount of air enclosed in the pleural cavity is very much less than the normal difference between the tidal air and the vital capacity, and naturally, therefore, there is comparatively little dyspnea. However, in the case of an open pneumothorax, there is an active competition for air going on between the trachea and the pleural opening. At each inspiration air not only enters the trachea but also enters the pleural cavity, and if the diameter of the pleural opening is the same as that of the glottis, practically the same amount of air will enter the pleural cavity as will enter the lungs and the animal will be compelled to increase his respiratory effort to get the tidal air into his lungs. If the opening is considerably larger than the glottis, it will be still more difficult to get the required amount of air into the lungs. When it is so large that more air than the difference between the tidal air and the original vital capacity enters the pleural cavity with each inspiration, the animal will no longer be able to obtain the requisite tidal air and death from asphyxia will occur. This theoretical discussion is,

of course, only an approximation and is not strictly accurate, since it is necessary to consider the actual amount of air entering by each opening rather than merely the differences in area, a consideration which also involves the relative lengths of the pleural opening and the trachea with the resultant friction to the passage of air. Observations, however, both clinical and experimental, tend to confirm the truth of this explanation. Clinically, it is well known that an individual of average size may have no alarming dyspnea from a pleural exudate amounting to 2,000 c. c. or 2,500 c. c. Exudates in greater amounts, however, frequently produce very severe dyspnea, particularly if the respiratory muscles are weak. Graham and Bell experimentally injected into the pleural cavity of a dog of 8 kilos, through a small needle, as much as 1,800 c. c. of air over an interval of 20 minutes without producing any marked asphyxia. Beyond that point, however, additional injections of only 50 c. c. at a time each had a very noticeable effect in increasing the dyspnea, and the animal died after about 2,100 c. c. of air had been injected.

The considerations of the effects of pneumothorax discussed above receive clinical confirmation from the experience in the World War with wounds of the chest. Reference has already been made to the fact that Army surgeons found not only that surprisingly large gaping wounds of the thoracic wall did not necessarily result in a fatal asphyxia, but also that bilateral "sucking" wounds were not inevitably fatal. These findings are easily explained, however, by the quantitative relationship between the size of the opening, the "vital capacity," and the other factors mentioned above in this connection. For it has been shown, on the basis of calculations described, that an average normal man, even without adhesions, can compensate for an opening of about 64.8 sq. cm. (10 sq. in.) until his respiratory muscles become fatigued or unless his need of oxygen becomes abnormally great. Practically, in operative procedures on the chest, measures are always adopted by the operator to reduce the size of the opening. An opening, which is apparently very large, is often actually much smaller, because of the presence in the incision of a lung which has been delivered out, gauze sponges, instruments and fingers of the operator or of his assistants, all of which by their plugging tend to reduce the area of the opening. The delivery of the lung outside of the chest wall also accomplishes, to some extent, the immobilization of the mediastinum. There is, therefore, apparently a perfect harmony between the conceptions of pneumothorax based on the above experimental results and the clinical observations on wounds of the thorax.

The theory of the action of pneumothorax which has been presented here is based very largely on the idea that the mediastinum offers only a negligible amount of resistance to changes of pressure in the thorax. From this it follows also that both lungs would be almost equally compressed by any sudden increase of pressure within the thorax, an idea which has been further substantiated by experiment. One can not, however, draw the conclusion that in chronically increased pressures the results are necessarily the same as in the suddenly induced increases. There are many reasons, indeed, for thinking that a difference exists and that, when a considerable amount of fluid has been in one pleural cavity for a prolonged period (several days or longer) the effect on the lung on the fluid side differs from that on the other side. It is a matter of common experience at autopsy on cases with pleural effusions, either simple or purulent, to find the lung much smaller on the side of the effusion. This fact has been one of the chief reasons in the past for

assuming that the mediastinum is a relatively rigid partition which would allow a marked compression of one lung without there being a noticeable effect on the other. Frequently, it has been used also as an argument against the theory of the effects of pneumothorax which have been stated here. In this connection it is necessary, however, to note the following facts: Adhesions are almost always present in cases in which there is a pleural effusion. These adhesions tend to stabilize the mediastinum and permit a marked difference of pressure in the two pleural cavities, a difference which can not occur in the normal individual without adhesions. The mere fact that one lung is smaller than the other does not necessarily imply that the smaller lung has been compressed. Even the absence of air from a part or the whole of the lung does not imply compression.

The results of the experimental work of Graham and Bell, as well as their conclusions, have been confirmed by others. Stivelman, Hennell, and Golembe [8] have reached identical conclusions both in experiments on rabbits and in therapeutic artificial pneumothorax work in the humans. They state:

> Graham and Bell touched the heart of the subject when they came to the conclusion that: "From the standpoint of pressure relations, the thorax may be considered as one cavity instead of two. Any change in pressure in one pleural cavity will affect also the other one almost equally." The results of our own experiments * * * also support this view. * * * In the presence of a flexible mediastinum the intrathoracic equilibrium in pneumothorax is very delicately adjusted, and any disturbance in the intrathoracic pressure on the treated side will have a proportionate effect on the intrathoracic pressure on the untreated side.

Experiments on animals by both Simon [17] and Betchov [18] have likewise corroborated the truth of the fundamental conclusions reached by Graham and Bell. Lenhart,[11] in a number of experiments on rabbits, came to the same conclusion. He states that his experimental results tend to confirm the truth of the conclusions drawn by Graham and Bell.[a]

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[a] Since the preparation of this manuscript in the summer of 1922, some of the theoretical aspects of open pneumothorax discussed here have been questioned. For example, Matas (The Value of Artificial Aids to Respiration in Acute Operative Collapse of the Lungs, *Archives of Surgery*, 1922, v. 110), Duval (Les données actuelles de la chirurgie intrathoracique unilatérale en plèvre libre, *La Presse médicale*, 1922, xxx, 409), Yates (Effects of Acute and Chronic Pneumothorax: A Preliminary Report, *American Journal of the Medical Sciences*, 1923, clxv, 1), and, more recently, Snyder (paper, as yet unpublished, delivered before the American Association for Thoracic Surgery at Chicago, May 30, 1923), have stated that in the dog a communication exists between the two pleural cavities. They infer from this that conclusions drawn from experiments on the dog are not applicable to the human. The conclusions of Graham and Bell are considered by some as being seriously compromised. The author of this chapter has answered these criticisms in part in an article in the *Journal of the American Medical Association* (June 23, 1923, 1825), and also in *La Presse médicale* (February 14, 1923, 141). The controversy has not yet been settled. The most important conclusion, however, has not been challenged, namely, that the "vital capacity" of an individual determines very largely the size of the pleural opening which is compatible with life, when there are no adhesions and no induration of the mediastinal pleura. The plan of treatment of acute empyema based on this conclusion has now been generally accepted in this country, and the results obtained have been good evidence of its general truth. As regards the less important details, the author has never been able to find the alleged opening in the mediastinal pleura in the normal dog, although there is no question about the diffusion through the mediastinum of various salts and dyes. In this connection important considerations are: (1) Can a unilateral pneumothorax be created in the dog? (2) Is there much difference between the dog and the human in the amount of deflection of the mediastinal structures which can be produced? The first question is answered in the affirmative and the evidence is submitted in the author's publications referred to above. In answer to the second question it may be stated that recent experiments performed by the author indicate that there is a close agreement of the dog with the human even when relatively high pressures are created in one side of the thorax. In either case the actual thinness of the mediastinal pleura is not of great importance, because when air is introduced on one side, the lung of the other side acts as a buttress against the mediastinal pleura, hugging it closely in every part of its area. The degree of deflection of the mediastinum, therefore, becomes related to the degree of compressibility of the opposite lung. However, one conclusion from the work of Graham and Bell is in error and should be corrected. It was stated that when an alteration of pressure is made in one pleural cavity of a normal thorax there is an alteration of practically the same degree in the other pleural cavity. This is true for pressures up to about 10 cm. of water, but they have found recently that for greater pressures it does not hold. For example, in the fresh human cadaver, if air is injected into one pleural cavity until a pressure of 21 cm. of water is obtained, the reading in the other cavity has been found to be 15 cm. of water; in the freshly killed normal dog the corresponding readings have been found to be 20 cm. and 13 cm. of water respectively. In Graham's earlier work with Bell the effects of pressures above 10 cm. of water were not determined. It was proposed to do this; but the experimental work was suddenly interrupted by the fact that Graham was sent to an overseas organization before the completion of the work. This later finding will also permit a slightly larger theoretical maximum non-fatal opening in the chest wall than was allowed in previous calculations.

During the World War, while the work of the Empyema Commission was in progress, the vital capacities of the patients were not investigated, but subsequently there was opportunity to make some studies of this character in civil cases. It is interesting that such studies have tended to confirm the validity of the mathematical expression concerning the maximum nonfatal opening. A case which shows this relationship is briefly described:

A young man who gave a history of having had pneumonia in the early part of February, 1922, and in whom pus had been found by aspiration, March 4, was admitted to the hospital March 7. An aspiration which was then performed resulted in the withdrawal of about 300 c. c. of moderately thick pus containing hemolytic streptococci. A question as to the existence of an active pneumonia induced the postponement of the operation for a few days. On March 12, immediately before the operation, the vital capacity reading was 1,600 c. c. and the tidal air 400 c. c. It was felt that, by this time, sufficiently firm adhesions would be present to circumscribe the abscess and prevent a general pneumothorax on that side. A resection of the eighth rib in the right posterior axillary line was made under nitrous oxid and oxygen anesthesia, and 400 c. c. of pus escaped. Immediately after the escape of the pus an alarming dyspnea occurred which was promptly relieved by plugging the opening. On releasing the plug of gauze the dyspnea recurred; and it was again relieved by applying a firm pad of dressings over the opening after a large drainage tube and a Carrel tube had been hurriedly inserted into the wound. Although the dyspnea was lessened after the opening had been covered, it persisted to an uncomfortable degree for several hours. On the second day a tracing of the wound was taken and its area was computed by means of an Amsler planimeter, which revealed an area of about 2.1 sq. in. If stabilizing adhesions were not present, therefore, the operative opening of 2.1 sq. in. allowed him a margin of safety of only 1.2 sq. in., and it is not surprising that severe dyspnea resulted. As further evidence that firm adhesions were not present at the time of operation, is the fact that one week later the cavity measured 1,300 c. c., although at operation only 400 c. c. of pus escaped, an indication that probably the alarming dyspnea was the result of a more or less general pneumothorax.

After establishing drainage of the empyema the vital capacity increases. The diminution of the size of the cavity usually goes hand in hand with an increase in the vital capacity. This relationship is shown in the following table compiled from observations made in another case:

Course of diminution of cavity and increase of vital capacity.

Date.	Capacity of cavity.	Vital capacity.	Tidal air.
	c. c.	*c. c.*	*c. c.*
Feb. 24, 1922	260	1,250	300
Mar. 3, 1922	90	1,750	300
Mar. 28, 1922	60	1,950	....
Apr. 17, 1922	25	2,300	300

AVOIDANCE OF OPEN DRAINAGE DURING PNEUMONIC STAGE.

In the light of what has already been said concerning the pathology of pneumonia and empyema, especially that due to the hemolytic streptococcus, and the physiological basis of treatment, it seems rational to conclude, that if an open pneumothorax is created by establishing drainage in a patient who is

already partly asphyxiated, such a serious burden may be added to him that he will succumb. He will certainly die if enough interference with his breathing exists to make his vital capacity equal his tidal air; for under such circumstances he will not be able to tolerate even a tiny opening in his chest. When the Empyema Commission substituted a method of repeated aspirations during the pneumonic stage with a deferred drainage operation, in place of an early open operation, at Camp Lee the mortality dropped from a little more than 40 per cent to 4.3 per cent. Similar striking reductions in the mortality occurred in other camps when early open drainage was abandoned. In a statistical article Stone [19] has shown the marked reduction in mortality which occurred at Fort Riley, Kansas, after the early open operation was abandoned. His cases are divided into three series and the following quotation from his article reveals the striking difference in mortality:

1. First series: Early operation (October 20, 1917, to January 21, 1918), 85 cases; mortality, 61.2 per cent.

2. Second series: Early aspirations and late operation (January 12, 1918, to August 10, 1918), 96 cases; mortality, 15.6 per cent.

3. Third series: Early aspirations and late operation (October 18, 1918, to February 14, 1919), 94 cases; mortality, 9.5 per cent.

Souligoux,[20] who advises early open drainage in all cases of acute empyema, states that the mortality of the streptococcus cases is never less than 25 per cent, a conclusion which seems to be significant in the light of the much lower mortality obtained in the United States Army when an early open drainage was not performed. In addition to the danger of an open pneumothorax there are certain other dangers inherent in even so minor an operation as the establishment of drainage. One of these is the possible creation of a septicemia. This danger exists particularly in the streptococcal cases. In fact, in several instances at Camp Lee, a positive culture of streptococci was found shortly after operation in patients whose blood immediately before the operation was sterile. The operations referred to were both simple intercostal incisions and rib resections performed early during the pneumonic stage of the empyema. The fact that positive blood cultures were very uncommon in other cases made it seem that doubtless some definite relationship existed between the early operation and the creation of a septicemia. This appears to be all the more likely when one recalls that a very close analogy exists between these streptococcal infections of the lungs and pleura and the ordinary streptococcal cellulitis cases which occur in other parts of the body. Experience has clearly shown in the case of ordinary streptococcal cellulitis, that free incisions during the acute stage aggravate the condition.

There are two ways by which some drainage at least can be accomplished without creating an open pneumothorax. One of these consists of repeated aspirations to be followed later by open drainage, and the other of the establishment of continuous closed drainage by means of a tightly fitting tube so arranged as to exclude air. Both aspiration and continuous closed drainage are old methods. Although each has had its enthusiastic advocates from time to time, neither method exclusively has given satisfactory results.

In 1844, before the Royal Medical and Chirurgical Society of London, Hamilton Roe [21] advocated aspiration as a therapeutic measure in empyema. He reported 9 cases of purulent effusion, of which 8 were said to have recovered and 1 died. Of 39 cases of pleural effusion of all kinds which had been reported

in British medical journals between 1812 and 1842 as having been treated with aspiration, only 11 had died. Roe emphasized the importance of early paracentesis, not later than three weeks from the outset. At the same meeting, Theophilus Thompson reported the recovery of a case of empyema in a child upon whom he had performed repeated paracentesis in the preceding summer, carefully excluding the entrance of air by tying "thin skin" over the end of the cannula during the procedure. In this country Henry I. Bowditch [22] was one of the first to employ paracentesis in pleural effusions of all kinds, and it was largely owing to his enthusiastic advocacy of the method that it became popular in America. He gave credit to Dr. Morrill Wyman of Cambridge, Mass., for the invention of the aspirating device which he used successfully on several cases.

A small percentage of cases of empyema will recover after aspiration alone, a few after a single aspiration, more after repeated ones. The method is not to be relied upon, however, and when used it should be only a temporary procedure for the purpose of tiding a patient over the acute pneumonic stage of the illness, with the expectation of establishing adequate drainage later. Of the acute cases studied by the Empyema Commission, 13 per cent recovered after aspiration alone. This agrees closely with Stone's [19] finding that at Fort Riley 11.3 per cent recovered. Holt [23] says that of 139 cases of children treated by aspiration, 25 recovered (18 per cent), 8 of these by a single aspiration, 13 died (9.3 per cent), and the remaining 101 were afterwards subjected to other treatment. Objections to the method of aspiration alone are, the difficulty of providing in this way adequate drainage because of the presence in the exudate of masses of fibrin and necrotic tissue which are too large to pass out through a needle or trocar; possible harm resulting from the puncture of the lung or a blood vessel with the needle, or from pleural reflexes; and the incontrovertible fact that most cases which have been treated by aspiration alone require a drainage operation later.

To perform paracentesis, a method should be used which does not permit the entrance of air into the pleural cavity. For this purpose the Potain aspirator is well adapted. The needle should be inserted into an intercostal space at the lower portion of the fluid. In most cases the site of election is in the eighth interspace in the posterior axillary line. The procedure can easily be made painless, or practically so, by an intelligent use of local anesthesia. To accomplish this, it is important that not only should the skin and subcutaneous tissues be anesthetized but the parietal pleura also should be anesthetized. One-half per cent novocaine is advantageous for this purpose. For the aspiration the patient should be in a comfortable position; it is not necessary that he should be in any particular position. The fluid should be withdrawn slowly, and the aspiration may be continued until either no more fluid is obtained or untoward symptoms supervene. Capps and Lewis [24] have shown experimentally in dogs that irritation of an inflamed pleura frequently leads to a collapse with a sudden drop of blood pressure similar to the syncope sometimes observed in the human during aspiration or irrigation of the pleural cavity. They found that artificial respiration was the most effective means of restoring the blood pressure.

If a method of repeated aspirations is to be carried out, the process can be repeated as soon as any considerable reaccumulation of exudate occurs. In

the Army epidemic it was found that it was desirable usually to repeat the aspiration in from four to six days. If repeated aspirations are made, the appearance of the fluid will change. In a streptococcal case, for example, where the fluid is at first serofibrinous, slightly blood tinged and thin enough to pass through the aspirating needle without much difficulty, it will gradually become thicker and more frankly purulent, assuming at the same time a slightly greenish tinge. If the aspirations have been made at intervals of three or four days, usually by the third or fourth aspiration it will be definitely frank pus. As a rule, also, coincident with the change in the character of the fluid, a general improvement in the patient's condition will have been noted, as shown by a diminution in the fever, the disappearance of cyanosis and extreme dyspnea, a better quality of the pulse, and an increase in the appetite. Frequently the path of the needle becomes infected, and occasionally an abscess forms in the soft parts.

Continuous drainage by a "closed" method, that is, one which does not permit the entrance of air to the pleura, is also an old practice, although, as Binnie [25] says, "in recent years it has been frequently rediscovered and modified in unessential details." One of the first enthusiastic advocates of it was Cresswell Hewett,[26] in 1876, who described his plan of "continuous aspiration" as follows:

> Paracentesis being performed with an ordinary trocar and canula, a caoutchouc (rubber) tube is placed through the canula into the empyema cavity; the canula is then extracted, and the outer end of the caoutchouc tube is attached to a glass tube, piercing the cork and reaching to the bottom of the vessel containing a weak solution of Condy's fluid or antiseptic. By gently lowering and raising the bottle the cavity is washed out, and by changing the first bottle for another and similar one the cavity is evacuated of pus, and filled with antiseptic solution; thus the pressure on the vessels in the wall of the sac is not much, if at all, altered, and hemorrhage and transudation are prevented. The amount of fluid to remain in the cavity is lessened day by day, by increasing the siphon action of the apparatus by keeping the bottle at a lower level, each day than the day previous.

Bülau [27] in 1891 proposed a method almost identical to that of Hewett except that he recommended irrigations with lime water through the tube. Since that time the principle of suction drainage has been rather generally, and particularly in this country, credited to Bülau, although Hewett had antedated him by 15 years. During the World War the principle was extensively revived again in the United States Army camps and subjected to modifications to such an extent that almost every camp had its own pet scheme for continuous suction drainage, for each of which the enthusiastic advocates made claims of vast superiority over all other methods.

Mozingo,[28] one of the most enthusiastic of the recent advocates of the principle of closed drainage, combines a system of closed drainage with irrigation by Dakin's solution and Murphy's fluid (2 per cent solution of formaldehyde in glycerin). Diederich [29] had employed a method very similar to Mozingo's at Camp Pike before Mozingo's arrival there. Mozingo reports a series of 138 cases, 45 acute and 93 chronic, treated by himself, with a mortality of less than 2 per cent. He regards an open drainage operation as practically never necessary and states that he has not found it necessary in his series of cases. It does not seem likely that an exclusively closed method could have such uniformly good results unless particularly favorable conditions were present, such as diminished virulence.

Theoretically, the early establishment of continuous drainage, with negative pressure, should have the advantages of keeping the pleural cavity relatively free from liquid exudate and organisms, of aiding the expansion of the lungs, as well as of avoiding an open pneumothorax with its attendant dangers. Practically, however, it seems doubtful if the results are appreciably better than with the method of repeated aspirations. There is, also, the additional risk, slight though it may be, that a delirious and unmanageable patient, by interference with the apparatus or the drainage tube, may allow air to enter his pleural cavity and may suffer from the effects of an open pneumothorax before it can be corrected. This danger was one of the considerations which deterred the Empyema Commission from adopting as a routine the establishment of continuous drainage, with negative pressure, although in some cases it was used.

Regardless, however, of whether repeated aspirations or a method of continuous closed drainage is used to tide the patient over the acute pneumonic stage, it would seem that every case should be regarded as one in which an operation for the creation of free drainage will be necessary at the proper time. It should be regarded as exceptional for a case of empyema not to require free drainage. If the exudate clears up under the conservative treatment and does not return, operation may be withheld, but the patient should be under close observation for at least a month.

Aside from the danger of creating an open pneumothorax during the pneumonic stage, there are certain advantages in a deferred operation. By the time the pneumonia has subsided and the exudate has become frankly purulent, a more or less diffuse cellulitis of the pleura has become converted into an abscess shut off by adhesions from the rest of the pleural cavity. An operation at this stage not only minimizes, therefore, the risk of creating an open pneumothorax because it is not necessary to open into the free pleural cavity, but it presents the safer aspect, well known to surgeons, which the drainage of a streptococcus abscess always has over premature incisions into cases of cellulitis before an abscess has formed. Even if an open pneumothorax should, by chance, be created, the patient is in a much better condition to withstand its harmful effects, because the subsidence of the active pneumonia has the effect of making the area of the air inlet to the lungs larger than when many of the bronchioles and much of the lung parenchyma are blocked by the pneumonic process, so that the pleural opening is incapable of producing the same amount of harm; the pressure of adhesions and the inflammatory thickening and induration of the mediastinum tend to make the mediastinum less mobile; the patient's need of oxygen is less because of an approximately normal metabolism; and the respiratory compensation is more efficient since, owing to a diminished toxemia, the respiratory muscles will not become so easily fatigued.

The danger of early open operation has been recognized by Legendre,[30] who divides patients with empyema into two classes. The first class comprises those with "white dyspnea" in whom the dyspnea is moderate, the respiration rate being about 25 to 30 per minute. The pallor is due to toxemia. The pulmonary lesions are either extinct or nearly well. In such cases a considerable time has elapsed since the beginning of the infection. After operation the fever subsides promptly, the dyspnea improves progressively, and recovery is the rule. The second class comprises those with "blue dyspnea," in whom the rate of respiration is from 45 to 50. There is marked cyanosis of the face

and extremities. These symptoms are in proportion to the pulmonary and not the pleural lesions. Operation increases the dyspnea, has no effect on the fever, and is generally promptly followed by death.

The only aspect of an acute empyema which may require an immediate interference for relief is the presence of alarming or distressing dyspnea. The only type of dyspnea which may arise and which is amenable to relief by intervention is that induced by an excessive pressure within the thorax. This pressure may be the result either of an excessive amount of fluid exudate alone, or of a combination of a spontaneous, rapid accumulation of air within the pleura, in addition to the fluid. In either case prompt relief can almost invariably be given by aspiration. Pneumococcal empyema differs considerably from streptococcal empyema in the fact that ordinarily it is not recognized until after the subsidence of the pneumonia. In this sense it is "metapneumonic," as suggested by Gerhardt.[31] When it is recognized, therefore, many of the conditions are usually found to be present which one strives to accomplish in the streptococcal cases by the preliminary aspirations. Doubtless it is mainly for this reason that, formerly, when early open drainage was extensively practiced in empyema, the mortality in the pneumococcal cases was generally much lower than in those due to the streptococcus.

These considerations lead to this pertinent question: In a case which has had a preliminary treatment by aspirations or by continuous closed drainage, when should an operation for drainage be performed? There can be no hard and fast rule for deciding, but when the exudate has lost its serofibrinous nature and has become frankly purulent, thus indicating that the pneumonia has subsided and that adhesions have formed to wall off the abscess, operation may safely be performed. Ordinarily, 3 or 4 aspirations are performed during the course of from 10 days to 2 weeks.

As to the type of operation employed for drainage, either an intercostal incision may be used, with the idea of later removing a portion of a rib if necessary, or a rib resection may be done at once. Moschcowitz preferred usually to begin with a simple intercostal incision. Certain cases will recover merely by use of an intercostal incision but the majority will probably heal more quickly if a portion of a rib is removed to provide more adequate drainage. One of the disadvantages of rib resection over simple intercostal incision is the greater danger of a chronic sinus from an osteomyelitis of the rib. Either operation can usually be performed satisfactorily with novocaine anesthesia, although there is probably no objection to the use of nitrous oxide and oxygen. The following method of inducing local anesthesia was employed by the Empyema Commission: Infiltration of the whole field of operation beginning with the production of a small skin wheal by use of a hypodermic needle and syringe, and supplementing the local infiltration by blocking the appropriate intercostal nerves in the subcostal grooves close to the spine. Because of communicating branches from the adjacent intercostal nerves it is advantageous to block not only the particular nerve to the rib to be resected but also the one above and below, respectively. For example, if the eighth rib is to be resected, not only is the eighth intercostal nerve blocked but also the seventh and ninth. It will usually be found more satisfactory to combine the two procedures of nerve blocking and the local infiltration. The operation should then be painless.

The particular rib selected for resection depends considerably upon the location of the empyemic abscess. A rib at the lowest border of the abscess will

ordinarily be chosen, but never one lower than the ninth because of the danger of injury to the diaphragm. Most commonly the eighth or ninth rib in the posterior axillary line is the one selected. Anterior drainage is never done except in the unusual cases in which the abscess is immediately behind the anterior wall. Chevrier [32] found on the cadaver that resection of the sixth rib in the posterior axillary line permitted the retention of 650 c. c. of fluid in the recumbent posture and from 1,250 to 1,300 c. c. in the erect posture; while the resection of the eighth rib in the scapular line caused the retention of 300 c. c. in the recumbent posture and from 150 to 200 c. c. in the erect posture. Observations on the cadaver, however, are not entirely applicable to the living, because after death the cessation of respiratory movements eliminates to a great extent the power of the thorax to empty itself. The movement of the diaphragm must be important in this respect. Binnie [25] states that an opening made at the angle of the seventh, eighth, or ninth rib will drain the cavity absolutely when the body is recumbent.

After making the rib resection it is advisable to have the patient cough or strain a little. This procedure will frequently force into the surgical opening large masses of fibrin. These masses of fibrin are sometimes as large as the palm of the hand, and if they are retained they delay healing. By this procedure they may usually be easily recognized and removed at the time of the operation. By digital exploration or by the use of an endoscope, large masses, which fail to appear by having the patient cough or strain, may sometimes be recognized. Some surgeons attempt also to break up adhesions with the finger. Logically, this would seem to be a practice to be strongly condemned; no one would think of similarly breaking up the adhesions around an abdominal abscess. One of the objects in deferring the operation is to localize the infection into an abscess. Why then disseminate the infection again? Likewise, the practice of attempting decortication in an operation for acute empyema is most unwise and will certainly do more harm than good in most cases.

In the practice of the Empyema Commission usually two rubber tubes, as suggested by Mitchell, which were beveled at the end and fenestrated, were passed into the cavity and anchored on the outside with safety pins. Preferably these should be of fairly stiff rubber (not soft enough to collapse of themselves) and with an inside lumen of about a half inch in diameter. The tubes ordinarily should pass just far enough into the cavity to permit retention. If there is difficulty in holding a tube in place a strip of adhesive plaster through the pin and attached to the skin will usually suffice to hold it in place. Through one of the tubes one or two Carrel tubes are placed in such a way as to insure thorough irrigation of the cavity. The fenestrations in the tube, even if they do not project into the cavity, permit some degree of irrigation of the sinus tract, a feature which is very desirable. If, instead of using free open drainage as outlined here, it is desired to practice some one of the closed methods of suction drainage, it may be done. Here again, however, in spite of theoretical advantages, after an extensive trial of both methods, one can not be convinced that practically any better results are obtained with methods of closed drainage. A device which was used in a large number of cases by the Empyema Commission is shown in Figure 60. Other measures which are sometimes resorted to for the purpose of excluding air are the use of valvular tubes of which many different kinds have been suggested. The simplest type consists of a tube the

external end of which is covered with a loose piece of thin rubber or of some similar material which will allow fluid to escape from the cavity but which on inspiration will be sucked up against the opening in the tube and exclude air. One of these, suggested by Moschcowitz and used by the Empyema Commission, is illustrated in its preliminary report.[2]

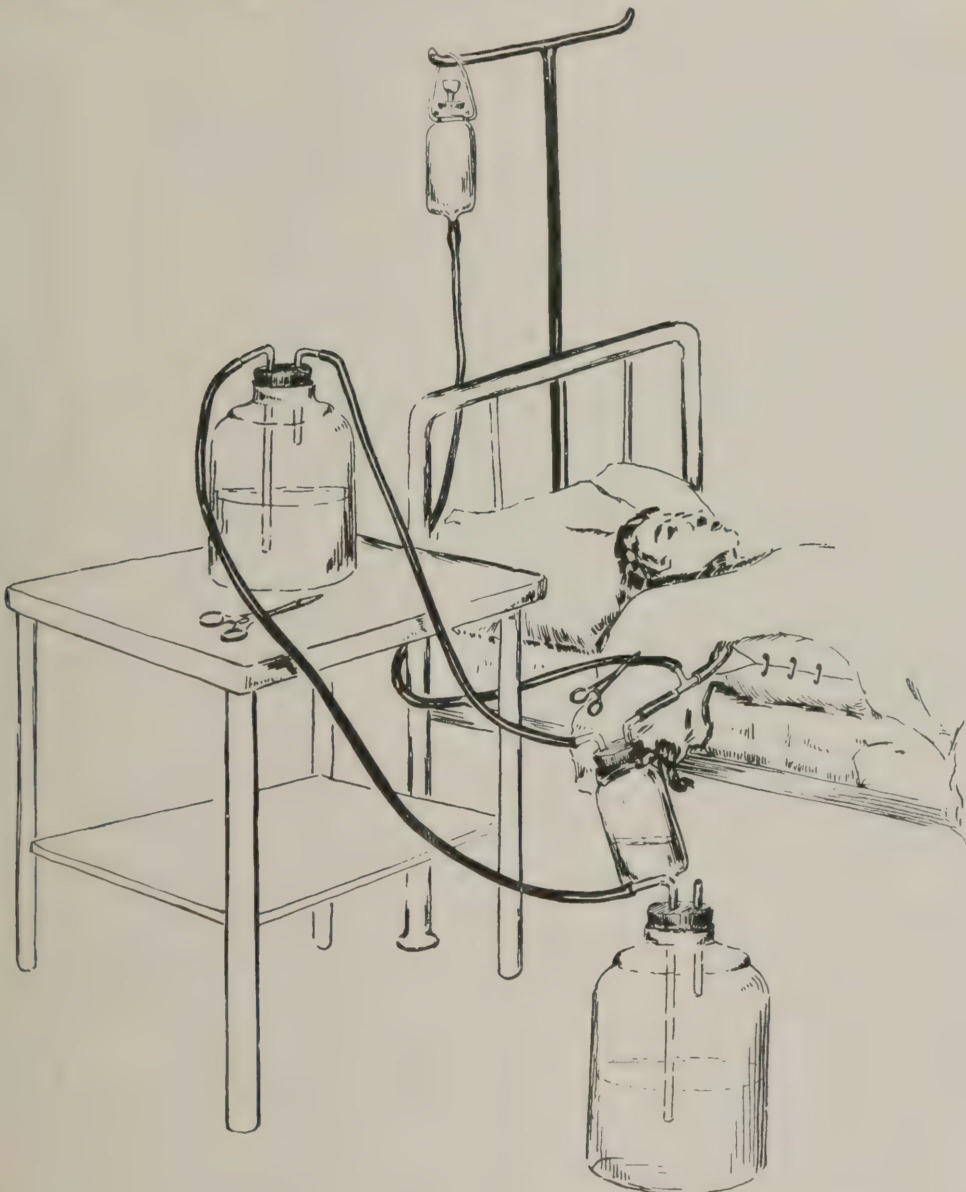

FIG. 60.—Apparatus for alternate aspiration and flushing of an empyema cavity.

Not only is there no apparent advantage in the use of closed, sucking devices for continuous drainage, but there are even certain disadvantages. One of the principal objections is that, with most forms of apparatus, it is necessary for the patient to remain in bed. This is a distinct disadvantage because it is very desirable for all such patients to be up and out of bed as soon

as the heart and general condition will permit. If, however, a valvular tube of some kind is used, such as shown in Figure 60, or such a device as that advocated by Von Eberts;[33] or, if a Politzer bag is put on the tube, as recommended by Bryant,[34] then it will be possible for the patient to be out of bed. Mozingo[28] has claimed as one of the advantages of his method that the patient can get out of bed early. But there are some objections, also. One of these is the difficulty in keeping the tube and connections air-tight for more than a few days. In accordance with a general rule, applicable to all foreign bodies, in the presence of suppuration there is a tendency for the tube to become loosened. Müller[35] and others have had the same difficulty. As soon as the tube becomes loosened a little pus begins to collect around it; and if rubber dam or some similar material has been used to seal over the wound, the pus spreads around under it and excoriates the skin.

The question of the advantage of early open drainage was put to experimental test in a series of 20 dogs in which empyema was produced. After several preliminary failures to produce an empyema by the intrapleural injection of from 10 to 15 c. c. of pure broth cultures of a virulent strain of hemolytic streptococci, a successful result was finally accomplished by injecting, into the pleural cavity of a 6-kilo dog 30 c. c. of a broth culture of the same strain which was highly virulent for mice. The dog died in about 12 hours after the injection, and at autopsy the left pleural cavity (the injected side) was found to contain about 200 c. c. of slightly blood-stained, serofibrinous fluid which contained myriads of streptococci and a few necrotic leucocytes. This exudate resembled in every respect the exudate obtained from the early human cases of streptococcus empyema at Camp Lee. Subsequently, this exudate was used successfully in doses of from 1 to 5 c. c. for the production of empyema in the series of 20 dogs. In 10 of the 20 dogs intercostal pleural drainage with cocaine (0.5 per cent) anesthesia was established within from 4 to 24 hours after the injection.

To the other 10 dogs which served as controls nothing was done. The operations were all carried out under strictly aseptic precautions and sterile dressings were later applied. A stiff rubber drainage tube with a one-quarter inch (6 mm.) lumen was used for each dog and the tube was stitched to the skin in order to hold it in place. The point selected for the drainage in each case was the sixth interspace in the anterior axillary line, since this seemed to be the most dependent portion of the thorax with the dog in the natural position. Each of 16 of the dogs received 2 c. c. of the exudate, two each received 3 c. c. and two each received 1 c. c. All the injections were made in the left pleural cavity. The dogs were paired as carefully as posssible according to weights, so that each dog operated upon had a control which was not only of approximately the same weight but which also had been injected with the same amount of pleural exudate. In general, out of each pair, the dog which seemed the stronger, and the better operative risk, was selected for the operation in order to give the operation every possible chance, since many of the dogs were poorly nourished and were victims of mange. In spite of all this, however, of the 10 operated dogs all but 1 died (a mortality of 90 per cent), and of the unoperated dogs only 7 died (a mortality of 70 per cent). Of the series of unoperated dogs one fatality was also in a dog which on the fourth day, while apparently well,

was badly injured in a fight with another dog, and received extensive lacerations in the neck, the back, and the hind legs. Death occurred two days later, and at autopsy the pleural cavity contained no exudate and appeared normal. It seems probable that it would not have died if it had not been for the wounds received in the fight.

It was a striking fact that, of every pair of dogs which died, the one which had been drained died from one to two days before its control, with two exceptions in which both the operated and the control dogs died at about the same time. It never happened that, of a pair, the unoperated dog died before the operated one. The only dog of the operated series which survived pulled its dressings off and pulled out the tube on the next day after the operation. When seen shortly afterwards (within three hours after the dressings had been pulled off) the pleurel opening had already closed so that the dog no longer had an open pneumothorax. This was the only dog which disturbed his dressings. As a rule, death occurred in the operated dogs from 48 to 72 hours after the operation and in the control series from the fourth to the fifth day. Of one pair, each of which had been injected with 2 c. c. of the pleural exudate, both the control and the operated dog died after about 24 hours following the injection. The operated dog in this case had been drained four hours after receiving the injection. The operated dogs, as a rule, not only died more quickly than their controls, but from the time that the pleural opening was made they all seemed more seriously sick than the unoperated dogs. They would lie quietly curled up, refusing food and resenting disturbance. The unoperated dogs were much more active. Immediately after operation each dog was placed in a cage by himself, was furnished with an abundance of water and food, and the cage was kept clean. In almost every instance the dressings were changed daily, dry sterile dressings being substituted for the soiled ones, with rigid aseptic precautions, even to the extent of wearing sterile gowns and sterile rubber gloves during the procedure. Each of the operated dogs had a profuse drainage of thin serofibrinuous discharge, sometimes slightly bloodstained, which microscopically showed innumerable streptococci and only a few leucocytes which were usually necrotic.

Each dog that died was examined at autopsy within a few hours after death. All of the operated dogs had been drained well, as shown by the absence of appreciable amounts of exudate in the pleural cavity. In practically every instance there was an extensive deposit of fibrin on the pleura, and there were many recent adhesions. In general, there were more adhesions in the dogs that had been drained than in the controls. Two dogs showed, in additon to a left pleuritis, involvement of the pericardium and the other pleura also. It was interesting to note that the pericardial fluid contained a noticeably smaller amount of organisms than the left pleural cavity and that the right pleural exudate contained even fewer. In other words, it appeared as if the infection had passed right through the pericardium and mediastinum from the inoculated left side. Of these two dogs, one had been and the other had not been drained. Three of the dogs that had been operated upon showed at autopsy pockets of pus behind the upper part of the sternum, which resembled very much those which had been described frequently in the human

cases. This condition was never observed in any of the dogs which were not drained.

The fact that in this series there was a slightly higher mortality in the dogs that had had early drainage than in a control series of the same number which received no treatment of any kind seems to indicate very strongly that, under the conditions of the experiment, early drainage at least is of no benefit to the animal, and, if anything, it is rather a source of harm. Presumably the harm is produced by the open pneumothorax, with the train of resulting effects which have been discussed earlier in this chapter. Any comparison, furthermore, with the condition of streptococcus empyema in man must carry with it the important consideration that, theoretically, this experimental empyema in dogs does not begin to contraindicate the early establishment of an open pneumothorax to the same extent as the human condition for the reason that the dogs do not have the associated pneumonia which seems to have been universally present in the human cases and which necessarily lowers the threshold of safety for the establishment of an open pneumothorax.

EARLY STERILIZATION AND OBLITERATION OF THE CAVITY.

The avoidance of an open pneumothorax during the pneumonic stage of an empyema will unquestionably result in a lower mortality. But a reduction in the mortality is not the only consideration in the treatment. Another principle of cardinal importance is the prevention of a chronic empyema. To accomplish this, it is necessary both to sterilize and to obliterate the cavity. Unless both of these conditions are fulfilled, permanent healing does not take place. There has been too much of a tendency among recent writers to consider as healed those cases in which the sinuses are closed and in which for the time being there is an absence of fever. It is impossible to be certain that an empyema has really healed until several months have elapsed without a recurrence.

Sterilization, when it really occurs, is actually accomplished by natural forces from within the body. Antiseptics will not sterilize living tissues, especially those antiseptics which are applied to the surfaces of infected tissues. Adequate drainage is by far the most effective artificial aid to natural sterilization which can be supplied. But in spite of apparently adequate drainage and in spite of irrigations with or without the use of antiseptics some cases of acute empyema become chronic.

The failure of these cavities to obliterate themselves has been due, in all probability, chiefly to an inability on the part of the lung of the affected side to expand sufficiently to fill its side of the thorax. This inability to expand is dependent chiefly on the following factors: Fibrosis of the lung as a result of inflammation and the thick, inelastic coat of exudate which covers the exposed surface of the lung and limits its inflation. This thick coat of exudate may be likened to a tightly fitting corset around the lung which obviously will interfere with its expansion, although, actually, it does not surround the lung.

Evidence of the failure of the lung to expand properly is presented at autopsies on cases of unhealed empyema. It is revealed by finding that the lung on the affected side is smaller than the opposite one, and that the exposed

surface of lung is coated with a dense layer of exudate which is sometimes fibrinous and sometimes organized connective tissue, in association frequently with a lake of pus contained within the thorax. The inequality in the size of the two lungs has frequently been ascribed to the collapse of the lung on the opened side from open pneumothorax, and it has been even used as an argument against the validity of the conclusion of the equilibrium of pressure throughout the thorax as developed in the experimental part of this chapter. It seems more probable, however, that there are other explanations. In the first place, widespread necrosis occurs with final destruction of areas of lung substance. As this necrotic lung tissue is removed by expectoration and by gradual absorption a considerable amount of fibrosis must occur during the healing process, which must necessarily result in the lung being smaller than normal. At the same time the opposite lung may undergo hypertrophy, since the presence of long-standing adhesions and inflammatory induration have immobilized the mediastinum to such an extent that the healthy lung is no longer subjected to compression by slight changes of pressure in the affected pleural cavity. The remaining air-containing portions of the affected lung, however, are not able to undergo hypertrophy to the same extent as they might otherwise do because of the thick coat of organized inelastic exudate which inhibits an adequate inflation of this lung.

It is obvious, therefore, that the early removal of this membrane is highly desirable. Because, at least in the streptococcal cases, organization of this exudate is known to occur early, it is clear that, other things being equal, the longer it is allowed to remain on the lung the longer it will take to obliterate the cavity. For the cavity is obliterated only when the lung is in contact everywhere with the parietal pleura. In the past, recourse has been had chiefly to mechanical means for the accomplishment of this purpose, as, for example, decorticating operations of the general type devised by Delorme.[3] Although in some cases these mechanical means have yielded brilliant results, on the whole they have been unsatisfactory. They have been associated with a high mortality and frequently they have not cured the patient. The fundamental defect in the rationale of such procedures is that attention is directed to only one of the two main objects of the treatment of empyema, namely, only to the obliteration of the cavity. It is fully realized that nature's efforts at sterilization are greatly aided by the obliteration of the cavity, but the frequency with which empyema recurs after the lung has apparently expanded to fill up the pleural cavity is evidence of the desirability of more active efforts directed toward the sterilization of the cavity.

In neutral 0.5 per cent solution of sodium hypochlorite (Dakin's solution) we have an agent which, on theoretical grounds, should be nearly ideal as an aid to drainage. For not only will it help materially to sterilize the cavity but, also, by its solvent action on the exudate, it will effect decortication and thereby help to obliterate the cavity. Clinical experience, based on thousands of cases in Army hospitals, has seemed to indicate very strongly that in the overwhelming majority of cases, if properly used, Dakin's solution will accomplish these purposes. Wilensky,[37] however, has questioned the superiority of Dakin's solution over simple irrigation.

For the details of its preparation and use the reader is referred to the book by Carrel and Dehelly,[38] and to Chapter IV of this section. The use of

Dakin's fluid should be begun immediately after the operation. The Carrel tubes which project outside of the dressings are attached to a bottle containing the solution, and the proper amount is allowed to run in. The custom of the commission was to give at first just a little less than the amount of exudate removed at operation; for example, if 250 c. c. of pus were removed, about 200 c. c. of Dakin's fluid would be run into the cavity at intervals of about every two hours during the day and of three or four hours during the night. The outside dressings can be changed as often as they become saturated. Once a day all the dressings are removed and the cavity is thoroughly flushed with the solution. Measurements of the capacity of the cavity are also made at the daily dressings, and as the cavity diminishes in size the amount of Dakin's solution is likewise decreased. It is believed that it is essential to use fresh solution which is not more than two days old and to protect the skin with vaselined gauze. If these precautions are carried out there will be few complaints of an irritation of the skin. Cultures should be made from time to time, preferably at intervals of three or four days, to note the progress in sterility. In a favorable case, after about three days there will be no more pus and in a week or 10 days no more bacteria will be found on culture. Usually, however, the pus has not disappeared in so short a time, and in the average case a much longer time is necessary for the elimination of the streptococci.

The cavity may not be obliterated, however, by that time. Two procedures are then possible. The drainage tract may be closed either by a simple plastic operation or by allowing it to close spontaneously after removal of the tube: or the irrigation and drainage may be continued until the cavity has obliterated itself, diminishing gradually the amount of solution used. The first method ignores the pneumothorax cavity in the belief that it will take care of itself without further trouble. This method gives quick, brilliant results in the successful cases but there is no doubt that it will also give more recurrences than the second method. Stewart,[39] Mozingo,[28] Moschcowitz,[40] and Heuer [41] have all advocated this procedure. It seems that the question is really one for the patient to decide. If he would prefer to take the risk of a recurrence in order to save perhaps a couple of weeks of time the method would be justifiable. At present it is not accurately known what the risk is, since there are no suitable statistics available showing the percentage of recovery. Certainly, the cavity should not be considered as sterile until at least two or, preferably three, successive cultures show no growth. No reliance should be placed merely on smears.

In a large proportion of cases (about 15 per cent of the streptococcal cases) difficulty in irrigation is encountered because of the presence of a communication with the lung, a pleuropulmonary fistula, which permits the irrigating fluid to run into the lung. In such instances violent coughing will immediately follow the attempt to irrigate and the patient will usually complain of the taste of chlorine, if Dakin's solution has been used. The great majority of these cases heal spontaneously in a few days. The usual procedure of the commission in handling them was to stop all irrigation for three or four days and then to try again. Usually on the second attempt no complaint of discomfort will be made. Sometimes by changing the position of the patient slightly it will be possible to irrigate even before the communication with the lung has healed.

The main value of Dakin's solution seems to be the fact that it sterilizes and obliterates the cavity chiefly through its power of dissolving necrotic tissue. Its direct antiseptic value is of minor importance, but yet it tends to prevent secondary infection. It is impossible to avoid the sucking of organisms into the wound, no matter with what care the dressings are done; and in the past patients with empyema have usually been infected with secondary organisms of all kinds so that the odor of a group of them in a single ward was often overpowering. The Dakin-Carrel technique certainly minimizes secon-

Fig. 61.—Free tissue plugging empyema drainage opening.

dary infection, and Army experience showed that it was possible to have 50 or more of these patients in a single ward without any disagreeable odor at all.

As a rule, the decorticating effect produced by Dakin's fluid is a gradual process which is accomplished by the slow solution of the false membrane of fibrin and necrotic tissue. In some cases, however, this membrane is removed suddenly in one large mass or in several smaller pieces. As evidence of the decorticating ability of Dakin's solution an epitome of a striking case is here presented.

Pvt. G., 22 years old, was wounded in the arm and leg in October, 1918, in the Argonne.[42] He developed a pneumonia on the left side, followed by

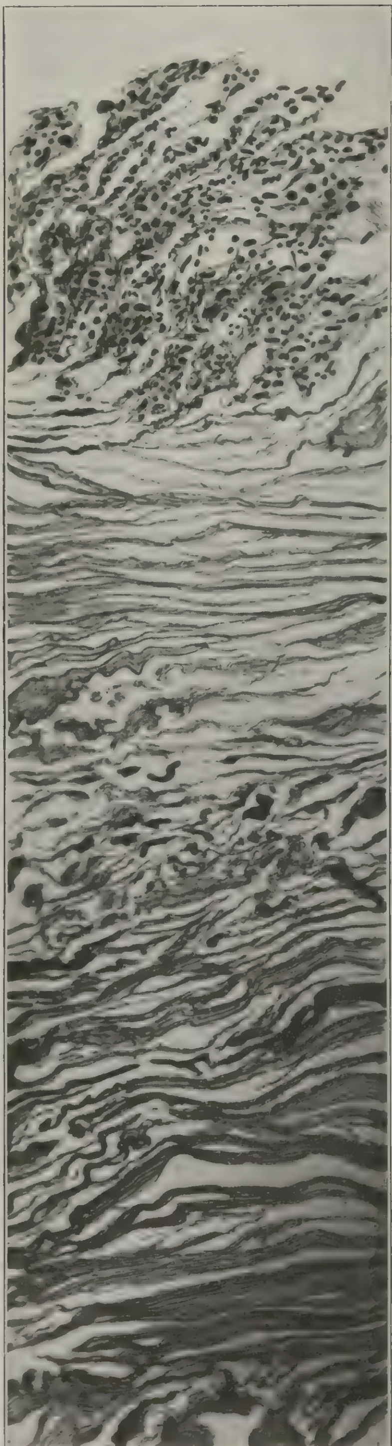

Fig. 62.—Microscopic section of tissue illustrated in Fig. 61.

empyema in November. He was drained through a thoracotomy incision. When first seen by Graham on June 2, 1919, at United States Army General Hospital No. 28, Fort Sheridan, Ill., he had a small opening in the seventh interspace in the left posterior axillary line which was draining a considerable amount of pus containing large numbers of hemolytic streptococci. According to the patient's own account, Dakin's solution had been used on him occasionally at some of the various hospitals in which he had been, but never systematically. He was markedly underweight, had a septic appearance, and had an afternoon temperature which ranged from 101° to 102° F. He had entirely recovered from the wounds of the extremities. A measurement of the empyemic cavity showed a capacity of 350 c. c. and the patient stated that a measurement which had been made two months previously had showed the same capacity. Under local anesthesia a portion of the seventh rib was resected, and immediately after the operation instillations of 200 c. c. of Dakin's solution at two-hour intervals were begun with provisions for adequate free drainage. On the sixth day a large piece of tissue was found plugging the drainage opening. Two days after the expulsion of this tissue the empyemic cavity would hold only 35 c. c. of fluid instead of 350 c. c. and no growth of bacteria was obtained from the secretion. Ten days later the patient was entirely healed and examination both by ordinary physical means and with the X-ray revealed no cavity remaining. On August 28 he returned from a month's furlough, apparently entirely well and having gained 35 pounds in weight. Two months later he was still entirely well. The rapid decortication with later sudden expansion of the lung to fill the cavity such as happened in this case is unusual, but yet it has been observed several times.

The piece of tissue was irregular in outline and flat. Its longest diameter measured

nearly 6 cm. and its widest diameter about 5 cm. It was nearly 0.5 cm. in thickness. It was yellowish-white in color, smooth except for folds on its surface, and in gross appearance it closely resembled fibrin; in fact, it was considered to be fibrin until microscopic sections were made. The microscopic examination, however, showed that the main portion consisted of necrotic, organized tissue. Except for a narrow strip of inflammatory tissue, which evidently indicated the side attached to the lung, the whole section was occupied by bands of wavy fibrils, arranged parallel to one another, with here and there the faint remaining outlines of what apparently had been blood vessels. The entire absence of nuclei except in the inflammatory zone was striking. The fibrils were readily stained by Van Gieson's stain for connective tissue, but they were not stained by Weigert's method for fibrin. Undoubtedly, therefore, the tissue was chiefly fibrous connective tissue which had become necrotic and was not unorganized fibrin. Throughout the inflammatory zone, and occasionally in the area just beyond, were seen irregular clumps of organisms. Many of these could be clearly distinguished as streptococci and they were Gram-positive.

Despite the advantages of irrigation which have been discussed above certain dangers are associated with it other than those due merely to a communication with the lung. Bleeding occurs sometimes, although it is usually only slight in amount. It is indeed rare that an alarming hemorrhage results from irrigation, although cases have been reported in which large amounts of blood have been lost. Usually, in cases of bleeding, if the irrigation is stopped for a day or two it may be resumed without further trouble. Attacks of syncope, which in a few instances have been fatal, have been reported. These have sometimes accompanied paracentesis or thoracotomy; and sometimes merely an irrigation has seemed to produce them. Wilson Fox,[43] in 1891, collected 17 cases of sudden death which he felt were due to some one of these procedures. Hippocrates is said to have observed the danger of fatal syncope in aspiration if the fluid were too suddenly removed. Some of these serious complications are doubtless due to cerebral embolism (Gee and Horder),[44] others are probably concerned with the pleural reflexes studied by Capps and Lewis.[24] In Graham's experience with about 400 cases of empyema treated by irrigations there were no attacks of syncope in association with irrigations of the pleural cavity.[3] On one occasion, while undergoing a rib resection under local anesthesia for empyema, a patient had two severe general convulsions on the operating table, became comatose, and died about 36 hours afterwards. At autopsy a diffuse streptococcal meningitis was found. On another occasion a patient under the care of a colleague died suddenly with an acute dilatation of the heart about five minutes after being at stool. It is well to bear these dangers in mind, but they are of such rare occurrence that they should not deter one from obtaining the advantages which irrigations offer. In this connection a study made by Stevens [45] on recurrence in empyema is important. Of 56 cases healed under simple drainage without irrigations, there were 14 recurrences, or 25 per cent; of 67 cases healed under the Dakin-Carrel treatment with drainage, there were 8 recurrences, or only 12 per cent.

CHRONIC EMPYEMA.

Chronic empyema may be found either as a previously unrecognized accumulation of pus in the chest, or in a case presenting a discharging sinus. It is remarkable that often a patient will go for a year or more with a very large

accumulation of pus within the chest, frequently containing large numbers of hemolytic streptococci, without sufficient local or general disturbance to make medical consultation seem necessary. The only symptoms complained of may be a cough, pain in the side, or loss of strength. On examination, however, in addition to the local evidence of fluid in the chest, there will also be found more or less emaciation, which may be extreme, fever of about 101° F. in the afternoons, leucocytosis, and often some degree of scoliosis. A Roentgen-ray examination and an exploratory aspiration will furnish the additional evidence, if this be necessary, for the diagnosis.

Discharging sinuses are of several different types. There are those which merely lead into relatively large cavities, those which communicate with the lung or with a bronchus but do not lead into a large cavity, combinations of the two, and sinuses which lead only down to the pleura or to a rib.

The most important causes of persistent sinuses are inadequate drainage, presence of foreign bodies, communications with the lung, cavities that can not be obliterated spontaneously, and tuberculosis or similar infections. In an experience with 138 cases of chronic empyema at Fort Sheridan in the spring and summer of 1919, by far the most common cause was found to be insufficient drainage of the empyemic cavity. It was apparent that one of the surest ways by which to turn an acute empyema into a chronic one is the failure to provide proper drainage. The various methods of closed drainage through small tubes and catheters have unquestionably saved lives during the acute pneumonic stage, but in many instances they have also been responsible for the transition of an acute empyema, which should have healed, into a chronic, unhealed one. It was appalling to find case after case which had been treated for 10 or 12 months supposedly by drainage, but in which the only provision for drainage was a tiny tube (often a Carrel tube) projecting from an opening no larger than itself, which led into a cavity containing 300 or 400 c. c. of pus, and even this tube often was tied into a knot to prevent the admission of air. Moreover, so much faith had been placed in suction that in very many cases apparently no attempt had been made even to make the drainage opening at a dependent part of the cavity. These are the great dangers from the unintelligent use of the various closed methods. The treatment of empyema is still surgical, and its proper handling requires the judgment of an experienced surgeon. It can not be turned over safely to an inexperienced person. Mozingo states as one of the advantages of this method of treatment: "The postoperative treatment in greater part may be done by a nurse or a properly instructed member of the family".[28] Doubtless, what he means is that most of the irrigations can be done by some one with ordinary intelligence, but there exists among general practitioners too much of a feeling that a method like that of Mozingo's has made the treatment of the condition practically automatic.

Foreign bodies constitute another important cause of persistent sinuses. Of these, the principal are sequestra of ribs, pieces of various kinds of drainage material, notably tubes and gauze, and, in gunshot cases, such things as shell fragments. Communications with the lung which may exist in association with persistent sinuses are of various kinds. One of these is the pleuropulmonary fistula. This is the most common type. It is due probably to the rupture of a small subpleural pulmonary abscess into the pleural space. The

communication with the lung may persist for a long time. Usually, however, it heals spontaneously. Another communication is the bronchial fistula. Here, the communication exists with a large bronchus. This type is less likely to heal spontaneously, and the fistula frequently becomes lined with epithelium. It may be so large that the patient may be able to breathe comfortably through it. Both of these types may communicate only with the main cavity, or, as often happens in the case of a bronchial fistula, the fistula may communicate directly with the outside, and no other cavity may exist. Fistulæ which communicate with the lung frequently lead into abscesses or into areas of bronchiectasis. Some sinuses merely lead down to a rib or cartilage which is the site of a chronic infection without the presence of definitely demonstrable sequestra.

Cavities that can not be obliterated spontaneously are in most instances due to improper management earlier in the course of the disease. They are usually found either in cases in which a free open drainage was instituted at too early a period or in cases in which adequate drainage has never been provided. In the work of the Empyema Commission it was found that most of the largest cavities and those which gave the most difficulty in obliterating were in the cases in which evidently an open drainage operation had been performed in the pneumonic stage. At Fort Sheridan, in 1919, it was found that the cavities which were the most difficult to obliterate without a plastic operation were in empyema cases which had existed for a year or more with very inadequate drainage. The principal causes are that, due to the persistence of the infection, the exudate on the lung becomes organized into fibrous tissue which thereby limits its expansion, and the fact that the lung itself undergoes fibrosis and contraction. At the same time the increased rigidity of the mediastinum tends to prevent the crowding over of the other lung and mediastinal structures into the diseased side, so that the cavity persists.

It is well known that pleurisy due to tuberculosis and other similar types of infection, such as actinomycosis, does not heal readily. Sinuses in such cases tend to persist. Of the 138 cases of chronic empyema at Fort Sheridan, 13 (10 per cent) were proven to be tuberculous.[46]

Every patient with a chronic empyema should be examined carefully with reference to the nature of the infection, the size and contour of the cavity and the presence of foreign bodies.

Cultures should be made from the secretion obtained from well within the cavity and not merely from the sinus. Other methods, of course, should be used for determining the presence of a tuberculous or similar infection, such as the microscopic examination of a piece of the wall of the sinus, and the examination of the sputum for the organisms.

Many variations exist in the nature of the cavities found. Some are large, occupying practically the entire half of the thorax; others may have a capacity of only a few cubic centimeters. Some cavities are unilocular but perhaps in the majority of cases of chronic empyema they are multilocular. The presence of adhesions causes constrictions in various places, in what may have originally been a single large cavity, with the result that all sorts of irregularities in shapes may occur. It is this irregularity in the shape of the cavity that is very often responsible for the chronicity of the case, because proper drainage has been

impossible under existing conditions. Especially is this the case in hour-glass constrictions.

It is very important, therefore, that as nearly as possible an exact diagonsis should be made of the size and contour of the cavity with which one has to deal. There are several methods available which are of great help. Instrumental exploration with a long flexible probe, such as a uterine sound, or with a pair of long curved dressing forceps will provide much information. The most valuable method of studying these cavities, however, is by means of the Roentgen ray. Tuffier [47] has used to his satisfaction a modified cystoscope which he inserts into the chest cavity and in that way gets a direct vision of the conditions present. Such a procedure is very helpful. It will often happen, however, that in order to obtain the necessary knowledge of what the conditions actually are, an operation will be required. Even sequestra from a rib will often fail to show in the Roentgen-ray plate because of the obscurity caused by a greatly thickened pleura.

TREATMENT OF CHRONIC EMPYEMA.

The kind of treatment recommended will vary greatly according to the particular case. The main indications are to provide adequate drainage, remove foreign bodies, accomplish sterilization, and then to supplement these, if necessary, with operative procedures to hasten the obliteration of the cavity. General hygienic measures are also very valuable.

It is well to begin the treatment of the ordinary case of chronic empyema rather conservatively; for it is often amazing to see how much can be accomplished merely by establishing adequate drainage and promoting sterilization of the cavity. The old sinus, therefore, should be enlarged to whatever degree may be necessary in order to secure a proper inspection and examination of the old tract and the cavity. This will almost always require the resection of a portion of one or more ribs. The ribs over the old sinus may be found fused together or in regenerating they may have assumed various bizarre shapes. It is not uncommon for the sinus tract to be surrounded by a ring of newly formed bone. Having explored the old tract and the cavity for foreign bodies, the object then should be to secure satisfactory drainage. To accomplish this it may be necessary to convert a multilocular cavity into one which is unilocular. This may require the separation of adhesions at various points and perhaps a considerable amount of greatly thickened pleura can be removed safely at this time. If the opening already made is not in a position which will drain the dependent portion of the cavity, either it should be extended downward or a new opening should be made. It can not be too strongly emphasized that free drainage is the most important indication of all in the treatment of these cases. In the ordinary case drainage should be provided at first. No sutures should be put into the wound but several Carrel tubes should be placed in advantageous locations, leaving one or two drainage tubes of large caliber in the wound to prevent too rapid closure. There is no fear of serious danger from pneumothorax in this type of case because the presence of adhesions and inflammatory thickening have stabilized the mediastinum. Irrigations with Dakin's solution are begun at once.

It was a frequent observation of the members of the Empyema Commission that often very large cavities which had remained practically stationary for months would become rapidly obliterated as soon as sterilization was accomplished by combining satisfactory drainage and irrigations with Dakin's solution. Hedblom[48] has presented an interesting table which shows the reduction in size of the cavities in 51 cases of chronic empyema (all existing over three months) accomplished by a combination of free drainage and irrigations with Dakin's solution.

Cases.	Capacity of cavity.	Average number of days of treatment.	Capacity of cavity at end of treatment.	Average percentage decrease in capacity of cavity.
			c. c.	
11	Less than 100 c. c.	35.9	10	90.0
16	100 to 250 c. c.	34.1	11–27.5	89.0
15	250 to 500 c. c.	56.4	11–22	95.6
5	500 to 1,000 c. c.	45.2	11–22	97.8
4	1,000 to 2,000 c. c.	32.0	80–160	92.0

	Cases.
Complete recovery	34
Sinus at last report	6
No late report	6
Convalescence not completed	4
No benefit (tuberculosis)	1
	51

The advantages of a plan of procedure such as outlined above are not only that many cases may be healed in this way with a minimum of risk and of deformity, but also, if a more severe plastic operation becomes necessary later, it can be done in a relatively clean field.

As already indicated, however, there are some cases which can not be healed by this comparatively simple procedure. For such cases a more elaborate operation will be required. Operations for this purpose, of which many have been devised, have been developed from two different basic ideas. One of these was that in order to obliterate the cavity the rigid chest wall should be made nonrigid in order to fall down upon the nonexpanding lung, and the other was to free the lung from its inelastic coat of fibrin and fibrous tissue in order to permit it to expand to meet the chest wall. The former was illustrated particularly in the operations devised by Estlander [49] and by Schede.[50] Estlander's operation consisted in the multiple resection of ribs; and Schede added to this the resection of the thickened parietal pleura. For details, reference may be made to the original articles or to any textbook on operative surgery. The other type of operation was originally suggested by Fowler[51] and almost simultaneously by Delorme.[52] It carried out the procedure now generally known as decortication, by which was meant the stripping off from the lung of the fibrous tissue which prevents its expansion.

There are many objections to operations of this type. In the first place they all carry with them a high mortality and a low percentage of complete cures, so that a patient has very little assurance of a complete relief from his

trouble even if he undergoes the serious risk entailed by the operation. This is well borne out in the following statistics of Tuffier:[53]

Operation.	Mortality, per cent.	Cure, per cent.	Percentage of cases requiring another operation.	Percentage of cases not followed.
Estlander	18	50	32	....
Schede	28	50	....	22
Delorme	15	48	....	37

Extensive decortication is usually accompanied by a large amount of hemorrhage. In many cases it is impossible to accomplish an extensive decortication because the fibrous tissue on the surface of the lung is only part of a more general fibrosis of the whole lung and projections of scar tissue extend from the surface deep into the substance of the lung.

The operations of the type of Estlander and Schede leave a very bad deformity which is not only anatomical but physiological as well.

Various modifications of these thoracoplastic operations have been suggested, some of which will be mentioned briefly. Souligoux,[54] recognizing the difficulties of decortication, advocates the separation of the adhesions at the periphery of the cavity. This mobilization of the lung allows those parts of it which are still capable of inflation to expand sufficiently to fill a cavity which otherwise it could not do. He combines with this procedure a modified Schede operation. Ransohoff advocates gridiron incisions in the pleura over the lung with the idea of allowing it to expand.[55] Robinson has practiced the transplantation of flaps of muscle, particularly the latissimus dorsi, in order to fill up a cavity with living tissue which will provide granulations.[56] Tuffier and Depage advocate closure of the pneumothorax cavity after cultures have shown streptococci to be absent and after the pleura has been shown not to secrete when dressed only with sterile gauze without the further use of Dakin's solution.[47] In other cases they perform various combinations of decortication and mobilization of the lung. Heuer also has closed some chronic empyemic cavities after sterilization, disregarding the pneumothorax.[41] Beck has transplanted flaps of skin into the cavity.[57] Lambotte, in 1911, had enthusiastically advocated the same procedure in intractable empyemic cavities.[58]

The treatment of fistulæ which communicate with the lung deserves mention. It has been stated elsewhere that the small pleuropulmonary fistulæ which occur commonly in acute empyema usually heal spontaneously. Sometimes, however, fistulæ of this sort persist. They then probably connect with a small bronchus. It is common to find small areas of bronchiectasis in the portion of lung into which some of these fistulæ lead. In such cases the fistulæ really act as safety valves discharging purulent material from the diseased portion of lung. They commonly attain the size of 2, 3 or more millimeters in diameter and they are often very long and tortuous. The external opening may be at a distance of 6 inches or more from the connection with the lung. These fistulæ pursue an almost typical clinical course. Spontaneous closure frequently occurs and continues for a few days, or perhaps a couple of weeks at a time, during which time the patient will have a sense of fulness in the side, will show some fever, and will often cough up pus. The

fistula then opens again spontaneously, pus drains out, and the patient is relieved of symptoms. There may be no empyemic cavity left in the ordinary sense, and the fistulous tract may be the only evidence that the original empyema has not healed. After experience with a considerable number of such cases, it appears that they should either be treated radically or be left alone. If radical treatment is undertaken the fistulous tract should be dissected up and a partial resection of the lung should be made, including the diseased area. It is not necessary to make an extensive resection, and the edges of the lung can be sutured together again with catgut, as in any other pulmonary resection which includes only a portion of a lobe. Less radical measures consist in excising the sinus down to the lung, cauterizing the pulmonary opening and suturing it across. In one case the stump of the sinus was buried in the lung and covered over with healthy lung tissue in much the same way as an appendix stump is buried in the cecum. The true bronchial fistula usually communicates with one of the main bronchi or with one of its principal branches. It may sometimes be almost large enough to insert a finger into it; and not infrequently it is possible for a patient to breathe through it comfortably with his nose and mouth occluded. Recent bronchial fistulae, even of large size, may close spontaneously. In one patient upon whom a lobectomy was performed a bronchial fistula, which was large enough to permit respiration through it, was present for six weeks. Three weeks later it was entirely closed, and it stayed healed. Those which persist for several months, however, are usually permanent and require operative correction. The most satisfactory results are obtained when the fistula is dissected up to its communication, cut off, and the opening closed, after cauterization of the epithelium. Eggers[59] has written an article dealing exclusively with this subject which gives some good points in the treatment of the condition.

Another method of limited value in the treatment of chronic empyema and of chronic sinuses in the chest is the use of Beck's bismuth paste. On the average the results in the Army were very unsatisfactory. When fistulae are present the paste is very likely to be disseminated through the affected lung and even into the other lung. If sequestra or other foreign bodies are present the paste will serve only to prevent drainage by plugging the opening. There is always also the danger of bismuth poisoning.

As in the treatment of acute empyema, it is important to give a generous mixed diet. The rapid gain in weight which occurs in these cases after establishing satisfactory drainage is often astounding; it is common to have a gain of as much as 30 or 40 pounds in the first month. It is advisable also to keep these patients out in the open air continuously if possible. Blowing exercises are helpful as in acute empyema.

Another procedure which was found to be of value in these cases is blood transfusion. Conditions in the Army hospitals afforded a very unusual opportunity of obtaining blood from those who had just recovered from the same infection. This blood probably contained enough immune antibodies to have very superior advantages over normal blood. One patient, transfused by Moschcowitz and Stevens, made an almost miraculous recovery. At the time of the transfusion he had, in addition to a very large cavity, a severe nephritis and a heart murmur. It seemed hardly possible that he could live, but he made a complete recovery with obliteration of the cavity.

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CHAPTER VIII.

THE SURGICAL TREATMENT OF THE REFRACTORY EMPYEMA CAVITIES.

When the crest had been reached in the treatment of strictly postwar surgical cases and the number of these cases had begun to wane, the Army found itself confronted with a large number of chronic empyema patients, the residue of the influenza epidemic of 1918 and 1919. The well-recognized measures of treatment, though applied with consummate skill and untiring patience by the ablest surgeons in the country, went unrequited so far as this particular group was concerned. It was necessary to discover in these apparently contradictory operative procedures and end results the reason or reasons for failure. This accomplished, it would then be possible to modify the methods previously in vogue so as to effect a cure and, at the same time, if necessary, to controvert opposing opinions. All the patients in question were poor surgical risks, depleted both in mind and body, and any attempt at surgical repair had to be done step by step, but never until the full confidence of the patient had been gained.

An experience before the World War first led the author of this chapter to believe in the wisdom of the "open" type of operation as the logical method to pursue. At that time, he was attempting to do a decortication on a patient who had had five previous operations for chronic empyema, when the hemorrhage encountered became so profuse that it was necessary to clamp the bleeding points, leave the clamps in position and pack the remaining cavity. This, of course, was before the introduction of Dakin's solution, and the present method of its use, but subsequently, he was astonished to see the ease with which the antiseptic solution could be applied directly to every recess of the cavity, the rapidity with which the cavity became clean, and the promptness with which it was afterwards obliterated. That the obliteration was permanently successful was evidenced by the fact that this patient, an officer, remained constantly on active duty from the time in question, and that he served in France throughout the strenuous days of the World War. It seemed but logical that these conditions should be simulated in the treatment of the postinfluenzal cases of chronic empyema if the hemolytic streptococcus, a very resistant type of organism, with which they were infected, was to be rendered inert.

When the majority of the Army camp base and general hospitals throughout the United States were closed many cases of chronic empyema were still under treatment. These cases had been subjected to many operations in the attempt to obliterate the cavities permanently and to secure final healing of the wounds. The patients of this type were gathered into a few permanent hospitals, the greater number being transferred to Walter Reed General Hospital, Washington, D. C., where it was possible to study and to treat them with every possible facility, and where the "open type" of operation was put into practice in the fall of 1920.[1]

In this connection, it is well to enumerate briefly the principal etiological factors observed during the treatment of these cases. Patients who presented pleurobronchial fistulæ numbered 60.8 per cent, 90 per cent had osteomyelitis of the ribs, with or without sequestration, 75 per cent showed accessory pockets or diverticula, and 15 per cent had foreign bodies in the nature of rubber tissue, drainage tubes, or bismuth paste.[2] One hundred per cent were infected

with hemolytic streptococci, and 15 per cent had underlying constitutional conditions, such as tuberculosis and syphilis. The problem of the surgeon was to obliterate the cavities in these cases by a method which would not only result in minimal mutilation, but which would increase the vital capacity and yet result in a low mortality. The "open" operation, carried out in repeated stages, seemed to approach this ideal more closely than any other known method.

Inasmuch as the previous operative methods carried out at a time when these patients were better able to withstand operative trauma and overcome infection, had failed in the hands of competent surgeons, it seemed that an operation should be attempted which would not only obviate the causes of previous failure, but which would, by minimizing shock, be well within the limits of safety. It was obvious that these patients could not withstand an extensive operation. The cavities were badly infected, and since resected ribs projecting into such cavities often resulted in osteomyelitis with sequestration, it seemed that the logical procedure was to lay the cavities completely open for direct irrigation and inspection.

The reason for this open type of operation was more apparent when it was found that a large percentage of cases of chronicity and recurrence was due to diverticula, which had not been observed at the time of the earlier operations. These diverticula drained by minute sinuses into the main cavity, or in some cases into an unobliterated and infected pocket, anterior or posterior to the residual sinus tract, which had failed to heal when obliteration of the greater part of the cavity occurred. However, pleurobronchial fistulæ were the major factors resulting in chronicity, and any attempt to close these fistulæ in a septic field was useless and dangerous. With these complications playing such a prominent part in the chronicity of this condition, an operative procedure was necessary which would eliminate these factors and at the same time would permit a patient with low vital capacity and little resistance to undergo the necessary surgical treatment with minimal shock.

Since the complete procedure could not safely be done at one time, a fractional or step-like operation was adopted in which no previous step would be nullified by the lapse of time intervening between the subsequent phases.

At this point it is necessary to emphasize the fact that these patients had not been improving. The majority of the cavities had been draining and discharging pus for three or four years. In spite of the markedly thickened parietal pleura, an appreciable cavity still remained with a collapsed, non-functioning lung and with a pleurobronchial fistula in 60.8 per cent of the cases.

All these patients required some form of operation that would give them a complete cure; consequently postponement was out of the question, for as time elapsed, they would continue to grow progressively worse and become poorer surgical risks. It was therefore necessary to take the case in hand before some secondary condition intervened to snuff out what little vitality remained. Furthermore, from the economic standpoint alone, an operation of this character was justified, for if hospitalization could be terminated, and the patient healed and restored to at least a fraction of his former earning capacity, he became an asset rather than a liability to the community.

During the preoperative treatment the patient was placed on a high caloric diet. Cultures from the cavity were then sent to the laboratory to determine the type of infection present. Other routine laboratory examina-

tions, including red, white, and differential blood counts, estimation of the hemoglobin, Wassermann reaction, and urinalysis, were carried out. Examination of the sputum for tubercle bacilli was most important. The vital capacity was determined in the majority of the patients. Preliminary irrigation with Dakin's solution was instituted for a few days prior to operation to render the patient less septic. In the interim, careful blood-pressure readings were made. The blood group was determined and the blood checked against that of a prospective donor for transfusion. One-quarter grain of morphine sulphate and one one-hundred-and-fiftieth grain of atropine sulphate were administered one and one-half hours before operation. In addition one-sixth grain of morphine sulphate was given 30 minutes before the operation was actually begun. Paravertebral anesthesia, combined with superficial and deep infiltration in the region of the operation, was carried out with one-half per cent novocaine solution. Nitrous oxide and oxygen were subsequently given only to the point of analgesia. This procedure, in addition to relieving pain, served to allay fright and to render the patient less susceptible to his surroundings. A preoperative transfusion was necessary in markedly septic and emaciated cases.

In the first cases which came to operation, the upper portions of the cavity were first attacked, provided there was simple and dependent drainage, otherwise the lower parts of the cavities were exposed to establish effective drainage at the earliest possible moment. In the later cases it proved most satisfactory to expose the lower part of the cavity in all instances. An incision was made over that portion of the cavity which was to be exposed. The outlines of this cavity had previously been localized with accuracy with bismuth injections and Roentgen-ray plates. The superficial muscle layers were exposed, clamped with large forceps to eliminate hemorrhage, and severed. After the surrounding tissues had been infiltrated with one-half per cent novocaine solution each rib was detached from the immediate musculature for a distance of 2 or 3 cm. beyond the limit of the cavity. The main portions of the ribs were separated subperiosteally. It was imperative that the subperiosteal separation did not extend to a point where the rib was to be divided, but was stopped at a half inch from the point of rib resection.

Since 100 per cent of these cases were infected, it was advisable to avoid subperiosteal resection at the point of rib division for the following reasons: Osteomyelitis, with or without sequestration, was present in 90 per cent of these cases. In almost every instance it proved to be the cut end of a rib which had sequestered for one-half to three-fourths of an inch beyond the point of the previous resection by the well-recognized subperiosteal method. These infected rib ends subsequently became detached and were displaced into the pleural cavity by muscle movements or by pressure of the skin or scar tissue contracting over the site of the former operation. They, in turn, became secondary foci of infection. It was repeatedly demonstrated during the war that the Bunge[3] amputation, which calls for the removal of the periosteum one-fourth inch above the point of division of the bone, is invariably followed by sequestration when the bone is denuded to this extent. Even simple periosteal separation is also frequently followed by similar results, especially in cases for reamputation where there had been prolonged suppuration at some previous time. For these reasons the periosteum was cut flush with the rib on section. Sequestration has not been seen in any of the cases where this method has been followed. Because of the added difficulty which this procedure involves, since hemorrhage

is much greater here than where subperiosteal resection is practiced, every effort should be made to control the vessels in the vicinity of the ribs to be sectioned before they are cut through.

The onset of shock is usually simultaneous with the resection of the bony structures overlying the chest wall. Therefore, at this stage of the operation, the anesthetist was instructed to make careful readings of the systolic and diastolic blood pressures and to closely observe the pulse rate and general condition of the patient. It was an infallible rule to use these criteria as a guide to the extent of operative procedure to be undertaken at any one step. When the systolic pressure fell to 90 mm. of mercury, the operation was discontinued, even if the general condition of the patient was good and the pulse rate within the limits of safety, since experience had shown that in some cases a subsequent drop of 10 to 20 mm. would occur during the first hour or two after operation. The inclination is but natural for the surgeon to do as much as possible at one time provided the patient's life is not being endangered, but on two occasions during the first operations in this series when the surgeon was apparently within the limits of safety the patients rapidly passed into profound shock and died, although they had been on the table less than 40 minutes. The value of brief and repeated operations was thereby forcibly demonstrated.

FIG. 63.—Cavity illustrating the use of the skin as a protective covering.

Having resected the bony structures overlying the part of the cavity to be exposed, the parietal pleura was next excised and that portion of the cavity was exposed. After the cavity had been exposed to the desired extent, the skin was inverted over the severed muscle and anchored, together with the muscle over the resected rib stumps, by means of silkworm gut sutures. The object of this was to prevent the muscle and skin, which were necessary for the final closure, from retracting and becoming atrophied, and also to render the dressings less painful, since the sensitive areas were covered with skin as a protective covering (Fig. 63).

Multiple scarification was practiced on that portion of the skin sutured under tension to cause relaxation and to prevent sloughing. The dressing was then applied after 8 to 10 Carrel tubes, interspaced in layers with gauze, were placed in the cavity. The whole area was gently packed in this fashion. One Carrel tube, to be retained in place for 48 hours, was placed under each infold

of the skin and muscle. The outer dressings were then applied and the patient was removed to the recovery room if his condition warranted.

When necessary, restorative measures were promptly instituted to combat shock. These restorative measures comprised, principally, the local application of heat, the administration of a shock enema, composed of spiritus frumenti 60 c. c. and coffee 120 c. c., and the elevation of the foot of the table. Normal salt solution was administered intravenously, and blood was obtained for transfusion. The citrate method of transfusion was employed. The blood was given to the patient through the apparatus used to administer the normal saline If a second fall in blood pressure occurred and the symptoms of shock persisted a second transfusion was given. However, postoperative shock occurred rarely if the surgeon adhered to the fixed principles of the steplike operation. Only two cases in this entire series required a second transfusion.

Fig. 64.—Five subcavities. Three posterior cavities obliterated, and two anterior cavities still partly open.

All danger of shock being over, the patient was returned from the recovery room to his respective ward on the day following the operation. It was found to be imperative that the ward surgeon who dressed these cases daily be present at the operation so that he might be fully informed of the particular complications that existed and that he understand the objective to be reached as well as the complications that might ensue. The routine treatment adopted in the postoperative care of these cases was the classical Carrel-Dakin technique as employed in the sterilization of septic wounds. The number of tubes depended upon the size of the cavity. The cavity was packed throughout its entire extent to prevent any overhanging of wound margins. It was important that no portion of the exposed cavity be roofed over at any time by the encroachment of the contracting soft tissues or by unhealthy granulations. The dressings were changed daily and at the same time the wound was thoroughly flushed out with Dakin's solution and the packing reapplied. As soon as the patient's general condition had improved to the point where further operative procedure was warranted, he was again prepared in the manner previously described and more of the contiguous structures overlying the cavity was attacked. This procedure was continued until the cavity was eventually laid wide open in its entirety. In some instances as many as five subcavities were detected. The majority of these subcavities had not been

detected by the Roentgen ray and had not been discovered in former operations because of the very minute openings which would admit only the smallest probe. These openings, however, led to cavities, the capacities of which were from 15 to 50 c. c. The cavities were not evident before irrigation had been instituted for from 10 days to 2 weeks.

The collapsed lung was freed from its fibrous pleural covering in one of two ways, depending usually upon the character of the fibrous deposit. In the thin-walled, hemolytic streptococcus pleura, which was too adherent to permit a line of cleavage, the lung was freed by a 2 per cent alcoholic solution of gentian violet applied in the form of a pack.[a] This pack was applied for two consecutive days, after which the cavity was constantly irrigated with Dakin's solution until the entire blue coating of devitalized tissue had exfoliated. A second application of gentian violet was made if necessary. This solution was also used in very thick pleuræ but the action was slower, except when it was employed in conjunction with discission. On the first case this agent was used for three consecutive days, but it was soon discovered that the destructive action led to the breaking down of the superficial air cells, and herniation of the lung was at times alarming. In a second case the pleura ruptured, and there was hemorrhage in a third. Consequently, this dye was used with great care and never in the strength given except in the open type of operation. The other method of pulmonary mobilization practiced was a discission after the method of Ransohoff. The method of Ransohoff was used in preference to surgical decortication, which was usually employed shortly before closure and occasionally in the wards without anesthesia or pain to the patient.

Surgical decortication was practiced in some cases but it was found that the expansile power of the lung was lost much earlier than if chemical decortication was employed. By these methods, cavities of 500 c. c. capacity have been reduced to 50 c. c., but these or any other methods of decortication did not result in the expansion of a lung which had undergone fibrosis.

After a cavity of large capacity had been reduced to a minimum by expansion of the lung, seven consecutive sterile cultures of the wound were obtained when possible. The cavity was then ready for closure. It was necessary, however, to close some cases in which it was impossible to get as many as seven consecutive sterile cultures, but the results were satisfactory. The treatment of these wounds was exactly the same except that the temporary drainage was allowed to remain for an extra 24 hours.

Several other factors, aside from the corrective surgical measures, apparently entered into the obliteration of these cavities. Regardless of what has been written relative to the assumption that the diaphragm on the affected side does not ascend in the presence of dense adhesions, it did occur. The healthy lung also tended to push over into the inadequately filled pleural cavity of the affected side and in this way helped toward obliteration even when the mediastinum was fairly rigid. Granulation was a factor in reducing the size of small cavities.

The subsequent closure of these empyema wounds was accomplished in progressive phases, when it was deemed necessary, in the same manner that a graded method was used to expose them. Before taking up in detail the technique of plastic closure, however, the closure of bronchial fistulæ deserves

[a] The gentian violet obtained since the war has been useless as a decorticating agent even when the strength was increased to 6 per cent. The preparation used on the cases described in this chapter was a pre-war preparation that was on hand at Walter Reed General Hospital. What the active agent in this particular brand of gentian violet was is not known—whether it was an impurity or whether it was specially pure.

special mention, as this complication proved one of the most intractable. The fallacy of attempting to close these fistulae in the presence of sepsis requires further emphasis. Even in the presence of repeated sterile cultures the advisability of completely closing any fistula in cases of this type is questionable, for the surgeon could never be certain as to the complications which might arise. Even in the hands of capable surgeons closure has been followed by such complications as lung and brain abscesses. In this connection, it might be well to mention, and it is probably fortunate, too, that no absolutely reliable method of closing every bronchial fistula was found. While the recognized method of purse-string suture with inversion closed some, it was found far more satisfactory to reduce the size of the fistula by a partial suture and to allow it to close by granulation after local stimulating applications of a 2 per cent alcoholic solution of gentian violet. Some of the early cases were closed by suture and the implantation of muscle over the closed fistula. A Carrel tube was left in the wound near the closed fistula for 48 or 72 hours. Although this method was not considered ideal, it was far less dangerous than the implantation of a skin flap which would form a much more resistant barrier if complications should arise. The greatest success in the closure of fistulæ was obtained after a combination of procedures which included the mobilization of the lobe with the fistula and the area in which the fistula emerged on the surface of the lung, or the partial reduction of the size of the fistula by suture. Each procedure was followed by the application of gentian violet. The actual cautery was used in a few instances, but was successful only in those cases with very minute fistulæ which did not require much treatment. It was absolutely imperative that no attempt at final closure of the cavity be made while a patent pleuropulmonary communication existed. Through such an opening the pathogenic bacteria present in the upper air passages naturally found ready access to the more susceptible overlying soft tissues, and caused continuous reinfection. This was apparently the explanation for the failures which occurred following other operative methods.

Having progressed thus far in the treatment of the case, and having eliminated all the factors which might account for the chronicity of the empyema, the surgeon was ready to close the wound permanently. Local anesthesia and gas analgesia were employed. The skin was freed from the underlying muscle bodies and was undermined to the required extent. The muscles, which had been saved at the previous operation, were freed sufficiently from their attachment to allow complete resuturing over the residuum of the cavity. All the muscle tissue which might be required was utilized to obliterate the space and the parts of the severed muscles were brought in apposition by sutures so as to restore the normal contour of the chest wall as far as possible and to allow flexibility with a movable skin surface. This could be accomplished in all cases except in those in which the muscles had been destroyed by previous operations and by infection. During the dissection for the liberation of the skin and muscles preliminary to final closure all raw surfaces were kept covered with packs moist with Dakin's solution to check oozing and to maintain sterility. After all the redundant scar tissue had been excised, the edges of the skin and the underlying muscles were approximated by a figure-of-eight silkworm gut suture. Rubber dam and Carrel tubes were inserted along the suture line to permit drainage. Multiple scarification of the skin was resorted to wherever it

appeared that tension interferred with the proper circulation of the part. The dressings were firmly applied to prevent the occurrence of any spaces between the contiguous layers of tissue. The pressure also aided in obliterating the cavity.

Whenever a cavity was so large that complete closure was impossible in one operation, an attempt was made to close only the upper parts of the cavity in this manner, and the remainder was closed at subsequent operations. The Carrel tubes were removed in 24 hours, the rubber dam drainage in 48 hours, and the sutures in 7 days.

The following classification, based on the condition of the patients when they were admitted to the empyema service at Walter Reed Hospital, is presented for convenience of description:

Group I: Patients belonging to this group presented great postoperative deformities, cavities with a capacity of 300 to 500 c. c., osteomyelitis of the ribs, rigid chest walls, and diminished vital capacity due to the compression or fibrosis of the lung or both (Fig. 65).

Group II: No postoperative deformity was found in these cases, and they had only moderately sized cavities of 300 to 500 c. c. capacity. The chest walls were flexible and the lung tissue was capable of ready expansion when liberated from the resistant thick pleura (Fig. 66).

Group III: This group was characterized by no postoperative deformities, but it presented enormous cavities, varying in size from 1,000 c. c. to the entire capacity of the side involved. Collapsed lung with fibrosis was always present, as well as a rigid chest wall, which had resulted from osseous regeneration between the ribs (Fig. 67).

Group IV: In this group there were no postoperative deformities. The cavities were small, chest walls were flexible, and the lung tissue was expansile (Fig. 68).

Irregular group: Those in the upper row of the cases in this class have very little postoperative deformity. Those in the middle and lower rows had moderate postoperative deformities, due to rib resection and osteomyelitis before admission (Fig. 69).

Owing to the fact that such a large percentage of these cases had complications, such as osteomyelitis, bronchial fistulæ, secondary cavities, and multiple draining sinuses, they are not mentioned in the above groups, nor have they been used as a basis for a more intricate classification of this condition.

Naturally some modification of the technique described was necessary, usually to meet the exigencies of the type of case undergoing treatment.

In the treatment of cases belonging to Group I, where the deformity and destruction were so great that there was little or no available muscle tissue, and, in addition, the lung had undergone fibrosis, the existing deformity could not be corrected though the cavity itself was laid open. The bronchial fistulæ were closed preferably by mobilization of the involved lung or by local applications, except in the case of very large fistulæ, which were reduced in size by partial suture and afterwards completely closed by local applications of gentian violet. This technique eliminated all dangers incident to sudden surgical closure of these fistulæ. The extreme cases in this group showed no marked improvement in the vital capacity following operation.

In cases belonging to Group II the entire cavity was laid wide open by the many-stage operation. After all the bronchial fistulæ had been closed and the

Fig. 65.—A representative group illustrating Group 1 of the text.

Fig. 66.—A representative group illustrating Group II of the text.

lung had been decorticated, the cavity was obliterated by the expansion of the lung. The final closure was affected according to the technique already described. The greatest number of chronic empyema cases fell in this group. They should have a flexible chest wall and practically no deformity following operation.

In the cases of Group III, in which the entire lung was collapsed and bound down, the wounds were enlarged to remove the infected rib-ends and to permit direct irrigation of the cavity. The operation, furthermore, provided more dependent and better drainage. After all sinuses were laid open and sterilized every effort was made to expand the lung by chemical decortication and discission. After the maximum of expansion was obtained by these means, provided all infected and necrosed ribs had been removed, the remaining cavity was obliterated by some modification of the Wilms or Sauerbruch operations.

FIG. 67.—The type of case included in Group III of the text.

In cases belonging to Group IV little if any treatment was necessary other than irrigation with Dakin's solution after the cavity was laid open and the fistulæ closed, except plastic muscle closure following the sterilization of the cavity.

Further postoperative treatment was as follows: The patients were kept on a high caloric diet, their weights were recorded at weekly intervals, and daily calisthenics (deep-breathing exercises) were instituted as soon as healing had occurred.

The vital capacities were determined after the wounds were closed and were compared with the readings made on admission. There was an increase of from 500 to 1,500 c. c. in the lung capacity. This increase is of decided importance to the patient as an evidence of heightened resistance to respiratory infections. Improvement is further substantiated by the excellent physical condition of these patients and increases in weight of from 10 to 40 pounds.

In a series of 40 cases studied at the Walter Reed General Hospital, 21 were of from 3 to 4 years' duration; 5 were of 2 years' duration, and the remaining number varied from 6 to 18 months.

Twelve of this number had had radical operations of the most extreme form and 24 had had multiple thoracotomies with removal of one or more ribs when admitted.

The results in this series were as follows: Thirty-five closed; three died; one left hospital before ready for closure; one undergoing syphilitic treatment

FIG. 68.—A representative group illustrating Group IV of the text.

FIG. 69.—A representative group illustrating the "irregular" group of the text.

and ready for closure. One hundred and seventy-three operations were necessary to complete the work on these cases by the many-staged method.

CONCLUSIONS.

1. The chronic type of empyema, especially those with large cavities, should occur but seldom if early aspiration followed by negative pressure treatment is promptly instituted.

2. Empyema cavities can be obliterated by discission and chemical decortication plus implantation of certain muscle bodies.

3. The patient's vital capacity and resistance to intercurrent disease can be increased by complete eradication of infection and the methods of decortication already mentioned.

4. Chemical decortication, if used injudiciously, may result in rupture of the visceral pleura, dangerous herniation of the lung, and hemorrhage, but the expanded lung retains its expansile power longer than when surgical decortication is practiced. (It should never be used in such a concentrated form except in the open type of operation.)

5. The pleurobronchial fistula is one of the commonest causes of persistent cavities.

6. Subperiosteal resection of ribs at the point of division should be discarded and rib section flush with periosteum adopted.

7. Obliteration by expansion of lung which means increased vital capacity should be practiced rather than cavity diminution by collapse of the chest wall.

8. Sterilization of the cavity can often be accomplished even in long-standing cases, but re-infection will invariably occur if the parietal pleura is not removed in a case of over one year's duration, especially if it is of the hemolytic streptococcus variety.

9. Daily cultures of the wound are necessary to check the progress and to determine the amount of Dakin's solution to be used.

10. The many-step, open or fractional operation, has the following advantages:

(*a*) It permits direct inspection and Dakinization of the entire cavity.

(*b*) It permits the detection and eradication of diverticula which are often missed on X-ray examination.

(*c*) It aids in the detection of osteomyelitis and foreign bodies.

(*d*) It insures such immediate improvement in profoundly septic cases that they will permit further operative procedure being carried out with low mortality.

(*e*) It affords easy removal of the parietal pleura and discission or chemical decortication of the visceral pleura.

(*f*) It allows the detection and direct closure of bronchial fistula.

(*g*) The operation can be discontinued at any stage, only to be finished later when the patient's condition permits, with a mortality far below that of the standard radical operation.

As regards the treatment of this type of case, the entire procedure is based upon the recognition of the soundness of the contention learned in the school of experience, that there is no short cut or abbreviated method whereby a cure can be obtained. Like every new departure in surgery, the operative technique is naturally the paramount prerequisite of that particular method, yet, in this instance, constant and careful Dakinization, together with massive and irksome daily dressings necessary to ensure sterilization, are indispensable desiderata in obtaining an ample reward for all the hardship the patient has endured.

CASE REPORTS.

CASE 1.—R. G. H., age 33 years. September 8, 1918, developed influenza and pneumonia. September 18, 1918, complication, empyema, left, hemolytic streptococcus type. Aspirated twice. October 22, 1918, thoracotomy; resection of 10 cm. of seventh rib, midaxillary line, drainage; irrigation with Dakin's solution. September 10, 1919, decortication; resection of seventh, eighth, ninth, and tenth ribs; dependent drainage; patient received a number of minor operations to institute drainage. September 24, 1920, Walter Reed General Hospital, admitted to empyema service.

Condition on admission: Stretcher case; poorly nourished; anemic; present weight 117 lbs. (normal weight 155 lbs.); fingers clubbed; extremities edematous. Examination of chest revealed sinus discharging pus 9th interspace, midaxillary line, left chest, with a large irregularly shaped cavity extending from second to eighth rib, midaxillary line. Radiographs showed marked collapse, left lung; extensive scar formation and marked thickening of parietal pleura; much proliferation of new bone formation from resected ribs; and some osteomyelitis of rib stumps. Small secondary cavity or diverticulum extending into the hilus of lung. Capacity of cavity 300 c.c. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 13,950; red blood count, 3,810,000; urine negative; culture from cavity showed heavy growth of hemolytic streptococcus. Blood pressure: Systolic, 110; diastolic, 80; pulse pressure, 30. Vital capacity reading, 1,500 c. c.

FIG. 70.—Case 1: A high incision to evacuate a large extrapleural abscess incident to osteomyelitis of the ribs. The illustration shows the great emaciation of the patient on admission.

December 9, 1920, operation; resection of 15 cm. of third, fourth, fifth, and sixth ribs, posterior scapular line, left chest; cavity laid wide open and preparation for active dakinization. February 4, 1921, operation; resection of 10 cm. of seventh, eighth, ninth, and tenth ribs, posterior axillary line; excision of thickened parietal pleura forming roof of cavity; skin inverted over muscle and saved for final closure; entire cavity exposed over posterior aspect and active dakinization continued. (Fig. 70.) April 7, 1921, operation; resection of 10 cm. sixth, seventh, and eighth ribs, anterior axillary line, left chest; anterior aspect of cavity laid wide open for the continued dakinization; discission of visceral pleura to allow lung expansion and the thickened parietal pleura excised. May 6, 1921, operation; partial plastic closure, upper aspect of posterior cavity; implantation of a portion of subscapularis and infraspinatus muscles into apex of cavity; superficial muscles, which had been saved at previous operation, brought in apposition and sutured; skin closed by silkworm gut; multiple scarification of skin to cause relaxation; active dakinization continued. June 21, 1921, operation; partial closure, anterior aspect of cavity; superficial muscles brought in apposition and sutured; skin closed with silkworm gut; posterior aspect of cavity left open for active dakinization. July 18, 1921, operation; removal of segments of seventh, eighth, and ninth ribs, which had previously been resected in anterior axillary line and detached posteriorly when cavity was laid wide open; active dakinization continued. September 3, 1921; operation; resection of 5 cm. of regenerated tenth rib stump which had become osteomyelitic;

dakinization continued. November 9, 1921, secondary closure with implantation of superficial muscle body in remaining cavity formation: additional superficial muscles brought over the implantation and fixed, leaving the resected rib stumps extrapleural when skin was brought in apposition. This was done because this case was considered tuberculous, due to the extensive rib necrosis, and should there be any additional necrosis of the rib stumps, the condition would be extrapleural and localized. February 24, 1922, incision of scar in posterior scapular area; removal of necrosed rib stump which had been left extrapleural at last operation. This rib resection had no relation to empyema. Wound left wide open for active dakinization and observation. March 1, 1922, empyema cavity completely obliterated since November 20, 1921; lung well expanded. April 15, 1922, patient improving; exposed to sun daily; on calisthenics and lung exercises; appetite good; weight and strength returning. June 26, 1922, patient entirely healed; X ray showed all cavity formation obliterated; lung well expanded; general condition excellent; weight 140 lbs; vital capacity reading 2,300 c.c.

Fig. 71.—Case 1: A posterior view of the final result.

Factors that were combated in this case were hemolytic streptococcus infection, osteomyelitis of ribs and rib stumps with bridging and overlapping, secondary cavity and diverticula, and the necessity for the removal of an almost solid plate of bone due to marked regeneration with bridging and overlapping of previously resected rib.

Case 2.—C. G., age 33 years. October 21, 1918, developed influenza and pneumonia. November 16, 1918, complication, empyema, left, hemolytic streptococcus type; aspirated four times. November 22, 1918, thoracotomy; resection of portion of seventh rib. March 3, 1919; additional rib resection and drainage instituted. May 3, 1919, operation; resection of 20 cm. of eighth rib posterior axillary line, left chest; Carrel tube inserted and good drainage instituted. The patient was treated by this method until June 24, 1919, when he was transferred to General Hospital No. 19, Oteen, N. C., because of a diagnosis of suspected tuberculosis. August 7, 1919, operation; resection of portions of sixth, seventh, and eighth ribs; dakinization continued. October 31, 1919, Estlander type of operation with resection of portions of third, fourth, fifth, sixth ribs and a portion of the regenerated seventh rib, with partial collapse of left chest wall; drainage instituted. February 19, 1920, resection of portions of second, third, and fourth ribs midclavicular line, thus causing additional collapse of left chest wall. June 2, 1920, incision made over seventh, eighth, and ninth ribs and necrotic posterior stump resected. January 17, 1921, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; anemic; highly septic; poorly nourished; present weight 110 pounds (normal weight 175 pounds); fingers clubbed; extremities edematous. Examination of chest revealed multiple sinuses, in scars of previous operations, leading down to resected rib stumps, which had become osteomyelitic; marked deformity in contour of left chest due to previous collapsing operations; large cavity formation extending from first rib to tenth rib

FIG. 72.—Case 1: A lateral view of the final result.

FIG. 73.—Case 2, as admitted to Walter Reed General Hospital. Necrosis of all ribs, from the third to eleventh, with multiple sinuses.

FIG. 74.—Case 2: Regenerated necrosed ribs exposed for removal.

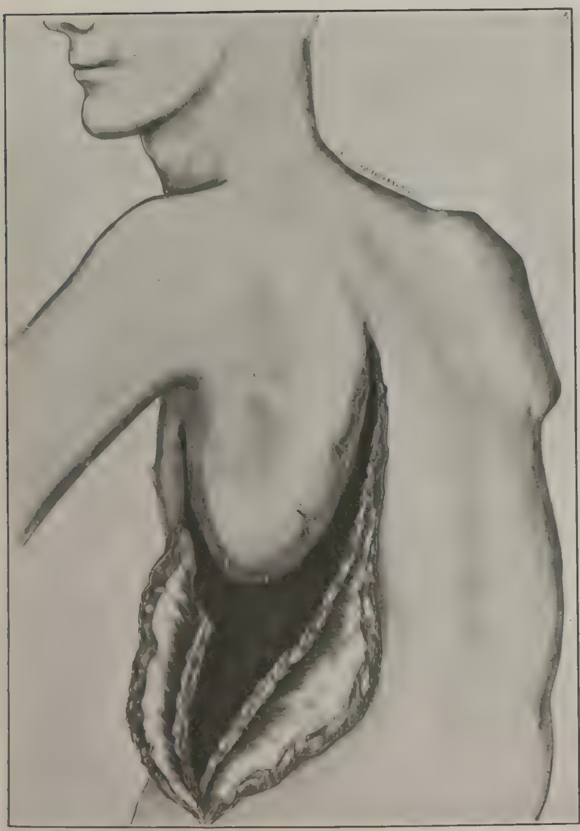

FIG. 75.—Case 2: The wound after the removal of the necrosed ribs.

lateral chest. Radiograph showed marked collapse of left lung with extensive thickening of the pleura from apex to base and a bismuth-filled cavity (capacity of 400 c.c.) with osteomyelitis and sequestration of rib stumps. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 10,300; red blood count, 3,640,000; urine negative; culture from cavity showed heavy growth of hemolytic streptococcus. Blood pressure.—Systolic, 108; diastolic, 80; pulse pressure, 28. Vital capacity reading, 1,500 c. c.

January 21, 1921, incision along posterior scapular line with resection of necrotic rib stumps; excision of thickened parietal pleura and scar tissue; skin inverted over muscle as a measure of preservation for final closure; cavity left open for active dakinization. March 16, 1921, resection of anterior portion of eighth, ninth, and tenth rib stumps with excision of roof of cavity; removal of all thickened pleura; discission of visceral pleura to allow lung expansion; active dakinization continued. April 8, 1921, resection of fourth, fifth, sixth ribs, midaxillary line; excision of thickened pleura; exposure of entire cavity; dakinization continued. May 7, 1921, resection of necrotic rib stumps; discission of visceral pleura to allow lung expansion; dakinization continued. June 3, 1921, partial plastic closure of lower part of cavity converging with diaphragm; implantation of portion of superficial muscle body at that point and a plastic skin flap sutured over defect; dakinization continued in upper part of cavity. July 11, 1921, partial plastic closure of upper posterior part of cavity by means of implantation of a portion of the subscapularis and infraspinatus muscle to obliterate the remaining portion which had not been obliterated by lung expansion; skin and superficial muscles brought in apposition and sutured; remaining portion of cavity left open for active dakinization. November 28, 1921, resection of necrotic rib stumps of third, fourth, and fifth ribs, anterior aspect; excision of overlying thickened pleura; removal of detached sequestrated rib stump from apex of remaining cavity formation; active dakinization continued. February 3, 1922, plastic closure of remaining cavity formation by means of implantation of superficial muscle bodies which had been saved at previous operation; remaining superficial muscle structure brought in apposition and sutured; excision of scar formation along skin margin and skin closed by silkworm gut; multiple scarification of skin to cause relaxation; rubber dam drainage for 48 hours. March 11, 1922, cavity completely obliterated; lung well expanded; X ray showed no evidence of osteomyelitis of remaining rib stumps; general condition good; patient gaining weight. June 21, 1922, excision of old adherent scar; plastic skin-closure of area with silkworm gut; multiple scarification of skin to cause relaxation; rubber dam drainage for 48 hours. June 28, 1922, skin area entirely healed; lung expanded and in apposition with chest wall; general condition excellent; present weight 125 pounds; vital capacity reading, 1,900 c. c.

FIG. 76.—Case 2: The open wound before the final closure.

Factors that were combated in this case were hemolytic streptococcus infection, osteomyelitis of rib stumps, numerous collapsing operations, left chest wall, with bridging and overlapping by regenerated rib formation, marked disturbance of respiration due to deviation of mediastinum. Patient could not withstand any fractional operation without all of the measures to combat shock.

Case 3.—R. C. N., age 25 years. October 6, 1918, developed influenza and pneumonia. November 1, 1918, complication, empyema, right pleural cavity, hemolytic streptococcus type; aspirated three times. November 11, 1918, thoracotomy; resection of 10 cm. of seventh rib, posterior axillary line; drainage instituted. May 19, 1919, resection of sixth and seventh ribs, 15 cm. at site of original thoracotomy; Carrel tubes inserted into cavity and active dakinization instituted. July 21, 1919, resection of 10 cm. of eighth rib, anterior axillary line; dependent drainage instituted in eighth interspace. September 3, 1919, modified Schede operation, resection of a portion of the fifth, sixth, seventh, eighth, ninth, and tenth ribs; roof of cavity removed; lung partially decorticated and mobilized; muscle and skin sutured; dependent drainage instituted by means of one Carrel tube. January 5, 1920, incision along scar of last operation; resection of the anterior and posterior stumps of fifth, sixth, and seventh ribs and a resection of 10 cm. of the fourth rib; decortication of visceral pleura at apex of cavity; dependent drainage, upper aspect of wound closed. April 23, 1920, excision of scar and sinus tract; cavity laid open; resection of anterior ends of previously resected ribs and a partial decortication of visceral pleura; upper aspect of cavity closed by muscle and skin; dependent drainage and irrigated with Dakin's solution. November 10, 1920, admitted to empyema service, Walter Reed General Hospital.


Fig. 77.—Case 2: The final result after closure of the wound.

Condition on admission: Poorly nourished; anemic; present weight, 140 pounds (normal weight, 185 pounds).

Examination of chest: Sinus discharging pus at the ninth interspace, midaxillary line, right chest, with a large cavity formation present. Radiograph showed marked collapse of the right lung with extensive thickening of visceral pleura, right lateral chest, from apex to base; ribs, fourth to tenth, inclusive, overlying cavity formation having been previously resected. Cavity formation extended from third to ninth rib with a capacity of 300 c. c. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacillus; white blood count, 14,200; red blood count, 3,620,000. Urine negative; culture from cavity showed hemolytic streptococcus. Blood pressure: Systolic, 110; diastolic, 76; pulse pressure, 34. Vital capacity reading not taken. November 18, 1920, incision over cavity, muscle and skin retracted; discission of visceral pleura; cavity left wide open and preparation made for active dakinization. December

27, 1920, resection of necrosed rib stumps; cavity left wide open and dakinization continued. February 9, 1921, lung well expanded and the greater part of the cavity formation obliterated; cavity sterile after seven consecutive daily cultures; patient ready for final closure. February 10, 1921, secondary closure of cavity; muscle and skin brought in apposition and sutured; silkworm gut with rubber dam drainage; multiple scarification of skin to cause relaxation. Following operation patient developed profound shock, and in spite of all the active combative measures taken, he died three hours later.

The factors to be combated in this case were hemolytic streptococcus organism; osteomyelitis of rib stumps; the amount of operative procedure that had been instituted, with resultant scar formation, made it almost impossible to find enough healthy tissue for closure.

Case 4.—R. C. K., age 22 years. March 17, 1921, developed measles. March 29, 1921, complication, pneumonia. April 8, 1921, complicated empyema, right pleural cavity, hemolytic streptococcus type. Aspirated five times. May 20, 1921, intercostal thoracotomy, right seventh interspace, posterior axillary line; drainage instituted by means of two rubber tubes. July 13, 1921, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; poorly nourished; anemic; present weight 105 pounds (normal weight, 155 pounds). Examination of chest: Sinus, discharging pus, seventh interspace, posterior axillary line; pleurobronchial fistula present and drainage not dependent. Radiographs showed a marked collapse of the right lung with some thickening of the parietal pleura and a cavity formation extending from the second rib to the base with an hour glass contraction of this cavity about the sixth rib, posterior axillary line. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 35,300; red blood count, 4,000,000; urine negative; culture from cavity showed hemolytic streptococci and gram-negative bacilli. Blood pressure: Systolic, 118; diastolic, 78; pulse pressure, 40. Vital capacity reading, 1,600 c. c.

July 25, 1921, operation; resection of 15 cm. of sixth, seventh, and eighth ribs, posterior scapular line; roof of cavity excised, and two sinuses leading into the upper and lower aspect of the cavity exposed; skin and muscle preserved for future closure; preparation of cavity for active dakinization. September 8, 1921, operation; resection of 15 cm. of fourth, fifth, sixth, seventh, and eighth ribs, posterior scapular line; roof of upper cavity removed and fistula exposed; contiguous lung tissue mobilized; skin inverted over severed muscles and cavity left open for active dakinization. October 12, 1921, operation; excision of adherent scar tissue and removal of small skin flap, institution of drainage of lower cavity which extended into mediastinum between the lower lobe of the right lung and the diaphragm. December 5, 1921, operation; secondary closure of upper aspect of the cavity, muscle and skin brought in apposition and sutured by means of silkworm gut; rubber dam drainage instituted; lower aspect of cavity left open for dakinization. January 10, 1922, operation; resection of 10 cm. of eighth, ninth, and tenth ribs, posterior axillary line; lower cavity, leading into the mediastinum, exposed after the thickened parietal pleura forming the roof of cavity had been excised; another pleurobronchial fistula exposed; cavity left wide open for active dakinization. March 1, 1922, fistula closed. Lower cavity one-fifth its original size. Cavity sterile. May 10, 1922, small cavity obliterated by lung expansion and ascension of the diaphragm. Entire area healed by granulation. The result being satisfactory, it was not deemed necessary to resect scar and make secondary closure. June 15, 1922, patient healed: fistula closed; all cavity formation obliterated; lung well expanded; general condition excellent: has taken on weight; weight on admission 105 pounds; present weight 112 pounds. Vital capacity reading, 3,100 c. c. Patient completely cured and discharged from hospital June 15, 1922.

Factors to be combated in this case were hemolytic streptococcus organism present; osteomyelitis with rib sequestration; pleurobronchial fistula: secondary cavity and diverticula.

Case 5.—L. J. McC., age 24 years. February 18, 1919, developed pneumonia. February 22, 1919, complication, empyema, right, hemolytic streptococcus type. Received 11 operations, including thoracotomies, Schede and Estlander types of operation, with resection of third to

eleventh right ribs, inclusive, and attempted resection of second right rib. November 15, 1920, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Patient acutely sick from accumulation of pus in old healed cavity, and about 25 pounds under weight. Radiograph showed a dense shadow over the right base suggestive of fluid. Pleura thickened from base to apex. Lung collapsed. Prior resection of the third to eleventh right ribs, inclusive, with bone proliferation and bridging. The external right chest resembled the contour lines of a map from the many previous lines of incision. Clinical laboratory examination: Wassermann, negative; sputum, negative for tubercle bacilli; blood showed slight anemia with high leucocyte count due to acute condition; streptococcus hemolyticus the prevailing and dominant organism in this case from the beginning.

January 10, 1921, patient showed evidence of reaccumulation of pus in chest. Needling with trocar canula and threading of small drainage tube into cavity permitted escape of pus. On attempting to use Dakin's solution, it was found that patient had a pleurobronchial fistula and the solution had to be discontinued. January 31, 1921, incision in line of previous incision in anterior axillary line; portion of fifth rib resected; cavity left open in preparation for active dakinization. April 11, 1921, exposure of cavity posteriorly and further exposure anteriorly with resection of necrotic rib stumps of sixth, seventh, and eighth ribs posteriorly and fourth, fifth, and sixth ribs anteriorly. The two incisions were separate and not connected externally but a narrow sinus led from one to the other within the cavity proper. Both wounds left widely open for dakinization. April 21, 1921, incision connecting the anterior and posterior wounds; dissection of connecting sinus tract internally with excision of intervening rib stumps. The chest now presented one large, deep wound of about 500 c. c. capacity. Cavity left widely open for active dakinization. May 18, 1921, small sinus tract found in upper angle of wound and excised. June 8, 1921, plastic closure. The bronchial fistula was still patent and had resisted closure by cauterization. At this operation the cavity, which had obliterated about 75 per cent, could be entirely obliterated by the implantation of muscle bodies lying along the upper and lower margins of the cavity. The bronchial fistula was closed by mobilizing it, inserting a purse-string suture and slightly inverting it; then the area was carefully covered in by a small muscle implantation sutured in situ. The skin and subcutaneous tissues were freely undermined on both sides and the tissue united by sutures under some tension. Rubber tissue drainage. Only superficial muscle slough followed. July 26, 1921, there was a little undermining of the skin in the middle third of the wound with slight slough due to tension. Superficial incision was made and the skin divided. Wound allowed to granulate. Following this the wound gradually healed. August 12, 1921, almost healed; Dakin's solution discontinued and gentian violet was used instead, as there was only a small place in the skin to close. September 2, 1921, patient healed; looked fine; felt strong; appetite was good; gaining in weight. October 1, 1921, patient granted two months' leave of absence. May 11, 1922, patient, after having been healed eight months, discharged cured.

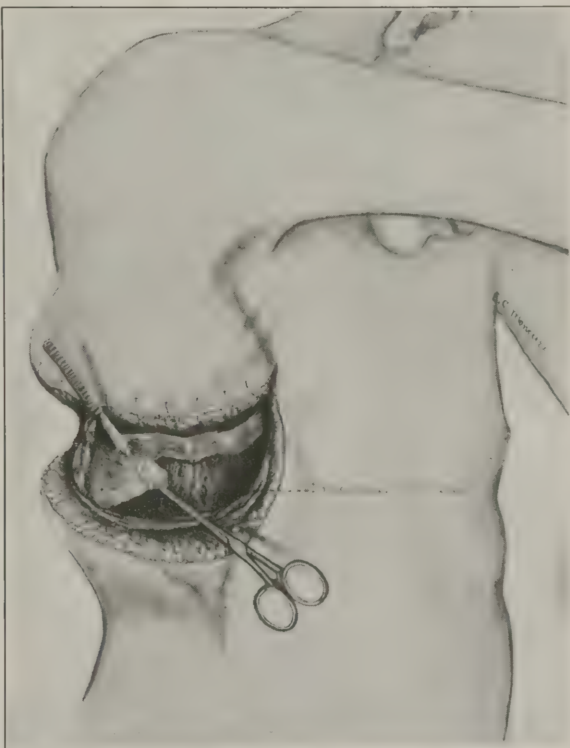

FIG. 78.—Case 5: Steps in the closure of the bronchial fistula.

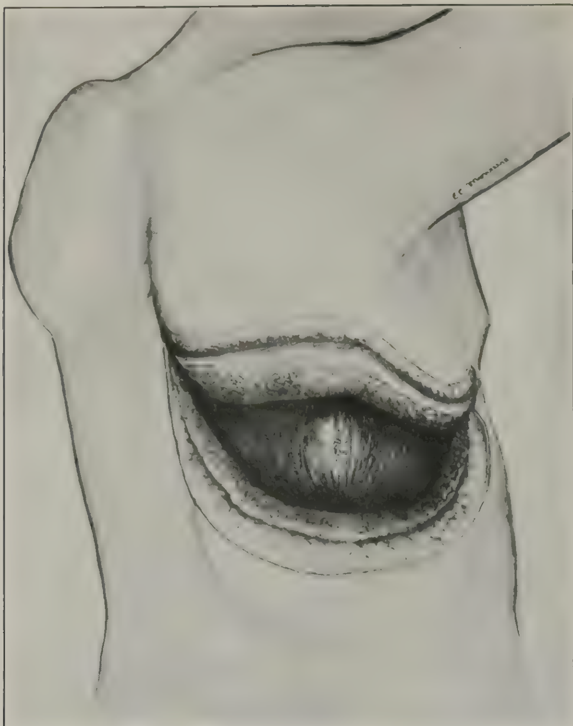

FIG. 79.—Case 5: Further operative procedure in the closure of the wound.

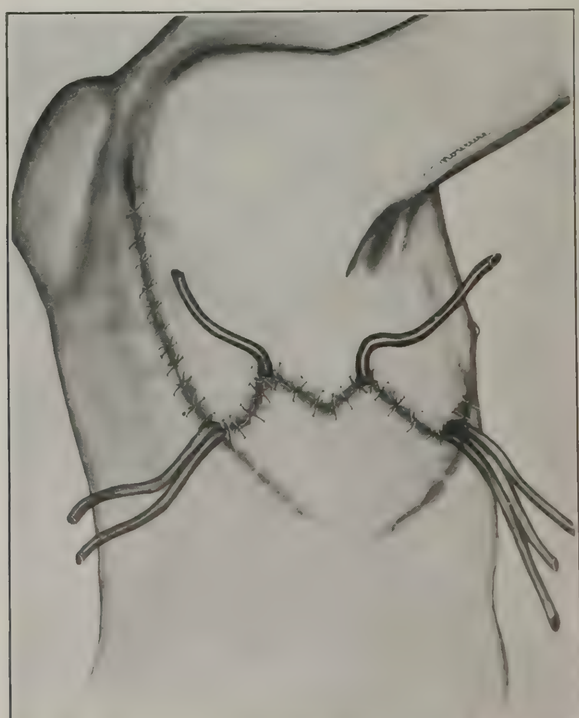

FIG. 80.—Case 5: The final closure of the wound, showing the method of inserting the Carrel tubes.

Factors to be combated were streptococcus hemolyticus, extensive collapse of lung with an almost total pneumothorax; numerous diverticula and recesses were infected and, having no drainage, were the foci of frequent recurrence; sequestra following extensive involvement of many of the rib stumps; at the time of the first fractional operation the chest wall was so scarred from 11 previous operations and there was such extensive cross-bone formation and bridging that operation for the removal of these structures overlying the cavity was made extremely difficult; pleurobronchial fistula present.

Case 6.—M. C. B., age 27 years. April 26, 1918, developed pneumonia, right lower lobe. May 1, 1918, complication, empyema, right. Aspirated May 2, 1918, and 500 c. c. of fluid removed. Aspirated every other day and fluid removed on 10 occasions. May 28, 1918, intercostal thoracotomy. Wound drained for five months following this. Patient had intermittent dakinization. August 15, 1918, bismuth paste injected into cavity and wound allowed to close. Capacity of cavity at this time was about 500 c. c. Wound remained closed until November, 1918, when the sinus reopened and drained for a period of three weeks. Sinus again allowed to close and remained closed until March, 1919, when it was again opened to drain pus until the latter part of May, 1919. Cavity remained healed until June, 1920. June 11, 1920, operation at a civilian hospital and part of the sixth rib resected. From this time until he was admitted to the empyema service, Walter Reed General Hospital, he continued to drain pus quite freely. January 10, 1921, admitted to empyema service, Walter Reed General Hospital.


Fig. 81.—Case 5: Final result.

Condition on admission: Patient anemic and undernourished; highly septic; weight, 132 pounds (normal weight, 150 pounds). Examination of chest revealed sinus at the level of the ninth interspace in the posterior axillary line, discharging pus freely. Sinus extended upward and backward and was apparently 20 cm. in length. Radiograph of chest showed resection of the sixth, seventh, and eighth ribs and a partial collapse of the right lung; thickening of the pleura from the base to the apex; definite osteomyelitis with probably sequestration of the sixth rib; the sinus passing upward and backward from the level of the eighth rib and terminating in an elongated cavity which reached the fifth interspace posteriorly. Measurements of the capacity of the cavity show that it held about 400 c. c. Clinical laboratory examination: Wassermann, negative; red blood count, 4,400,000; white blood count, 12,850; hemoglobin, 75 per cent; urine, negative; blood culture, negative; sputum, negative for tubercle bacilli; culture from exudate of cavity showed staphylococcus aureus and streptococcus hemolyticus.

Patient was placed on active dakinization for three days previous to operation. January 13, 1921, partial resection of the eighth and ninth ribs for drainage purposes only, with removal of the outer and lower wall of the cavity. Following this operation, patient was treated intensively with Dakin's solution until February 15, 1921, when the second step of the operative procedure was done. At this time there was resection of the fifth, sixth and seventh ribs, posterior, with an

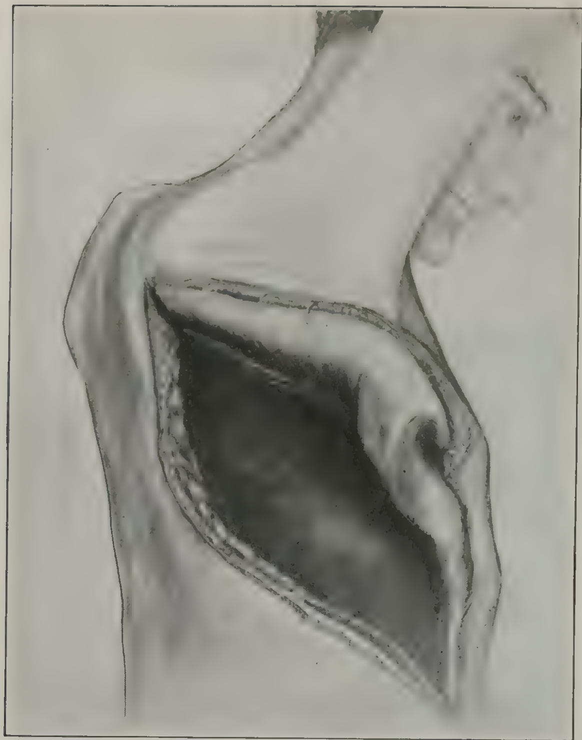

FIG. 82.—Case 6: The wound preliminary to muscle implantation.

FIG. 83.—Case 6: Muscle suture.

excision of all tissues forming the roof of the cavity. Cavity was left widely open and actively dakinized. April 8, 1921, the third operative step was undertaken. Sections of third, fourth, fifth, and sixth ribs were removed. Sterile cultures of the wound having been obtained prior to operation, it was thought advisable to attempt to obliterate the upper angle of the cavity by muscle implantation; so a part of the erector spinæ muscle was split and implanted into the apex of the wound and sutured in place. Practically all of the muscle thus implanted was retained and there was but little sloughing. The lower part of the wound seemed to be obliterating rapidly and the patient's general condition had improved considerably. May 2, 1921, X ray showed an osteomyelitis with sequestration of the terminal end of the previously resected third rib. The muscle body which had been implanted filling in this area was split and the sequestration removed. July 7, 1921, operation. A small fistulous tract found leading down to the ninth rib stump. This portion of the rib was resected and a plastic closure of the lower half of the wound, by implantation of the contiguous muscle bodies, was done. The skin was undermined on either side and brought forward, covering in all of the lower half of the wound. July 27, 1921, operation; plastic closure of the upper half of the wound by implantation of subscapularis muscle; sliding skin flap from either side brought forward and sutured. Rubber tissue drainage was placed in the line of closure and a firm dressing applied to the wound. October, 1921, patient entirely healed and feeling fine.


FIG. 84.—Case 6: Final result.

At the time of the first plastic operation the capacity of the cavity had diminished to about one-fourth of its original size. On discharge the X ray showed moderate collapse of the right chest wall; a rather marked thickening of the pleura but no cavity; the lung was well expanded. January 5, 1922, patient discharged cured, after having been healed three months.

Factors to be combated were hemolytic streptococcus organism present; osteomyelitis with rib sequestration; Beck's bismuth paste which had remained in cavity 13 months; three diverticula draining into main cavity.

CASE 7.—C. C., age 19 years. January 22, 1921, developed measles. February 12, 1921, complication, mastoiditis. February 14, 1921, mastoidectomy. February 15, 1921, complication, pneumonia. April 29, 1921, empyema, right pleural cavity, hemolytic streptococcus type. Aspirated once. May 3, 1921, thoracotomy; resection of 10 cm. of seventh rib, right anterior axillary line, with the institution of drainage and irrigation of cavity with Dakin's solution. June 9, 1921, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case, poorly nourished; present weight, 120 pounds (normal weight, 140 pounds). Examination of chest: Sinus discharging pus, right seventh interspace, anterior axillary line; drainage not dependent in this case. Radiographs showed partial collapse of the right lung with some thickening of pleura right lateral chest, and a cavity formation extending from the fifth to tenth rib lateral chest, right. Clinical laboratory examination: Wassermann, negative; sputum, negative for tubercle bacilli; red blood count, 4,540,000; white blood count, 10,350; urine, negative; culture from cavity showed heavy growth of hemolytic streptococci. Blood pressure: Systolic, 124; diastolic, 78; pulse pressure, 46. Vital capacity reading, 2,400 c. c.

June 28, 1921, operation; resection of ninth and tenth ribs, midscapular line, right chest, and the institution of proper drainage; cavity left open for Carrel-Dakin technique for its sterilization. November 8, 1921, operation; resection of 15 cm. of sixth, seventh, eighth, and ninth ribs, posterior axillary line, right chest, with the removal of thickened pleura over a cone-shaped secondary cavity; discission of visceral pleura to allow lung expansion; skin inverted over muscles to save them for final closure and to render dressings less painful; preparation of cavity for dakinization. December 13, 1921, operation; secondary closure of muscle and skin with a portion of the infraspinatus and subscapularis muscles implanted into the upper portion of the secondary cavity, which was not completely obliterated by lung expansion; the muscle and skin, saved at former operation, then brought in apposition and the entire area was closed with rubber dam drainage between sutures; skin scarified to cause relaxation and to prevent suture sloughing. December 28, 1921, patient entirely healed; feeling fine; appetite good and taking on weight rapidly. Radiograph showed total obliteration of the cavity and lung well expanded. January 20, 1922, general condition excellent; weight on admission to this hospital was 120 pounds; present weight, 170 pounds; vital capacity reading 3,300 c. c. March 3, 1922, empyema healed. Patient transferred to the ear, nose, and throat service for treatment for old salivary fistula at lower end of old mastoid wound. June 30, 1922, patient returned to empyema service for disposition. Fistula healed. Empyema healed. Patient ready for discharge.

FIG. 85.—Case 8: The wound before final closure, showing a persistent bronchial fistula.

Factors to be combated were hemolytic streptococcus organism present; secondary cavity draining pus into main cavity; primary drainage was not dependent; additional aspirations should have been done by negative pressure before rib resection and lung collapse.

CASE 8.—S. R., age 28 years. March 30, 1918, developed pneumonia. April 3, 1918, complication, empyema, right pleural cavity, hemolytic streptococcus type. Aspirated once. April 3, 1918, intercostal thoracotomy, seventh interspace, midaxillary line: drainage instituted; daily irrigation with Dakin's solution and dichloramine. June 10, 1918, another cavity found draining into the one that was opened, making capacity 450 c. c.: Dakin tubes inserted and classical Carrel-Dakin technique for the sterilization of wounds instituted through primary incision.

Daily aspiration of other areas of chest caused the cavity wound to close and the cavity to again fill with pus: drainage reinstituted by opening the original wound. Formalin and glycerin (2 per cent) were used but no improvement was noted. Treated by this method of procedure for some time, and when wound would close negative pressure treatment was tried.

January 14, 1919, operation; resection of a portion of the ninth rib, right posterior axillary line: dependent drainage instituted and active dakinization started. August 19, 1919, decortication operation with fish-hook incision and resection of fourth, fifth, sixth, seventh, eighth, ninth, tenth, and eleventh ribs: outer wall of cavity removed en masse: visceral pleura decorticated; muscle and skin closure with one drainage tube in dependent portion of wound. September 23, 1919,

healed. January 10, 1920, wound reopened. Large cavity present; bronchial fistula noted; hemoptysis with persistent cough: almost impossible to irrigate the cavity with any solution, due to the fistula. August 19, 1919, diagnosed as chronic parenchymatous nephritis in conjunction with empyema: cavity kept open and irrigated in spite of patent fistula. Hemoptysis persisted; dressed and treated in the manner stated until November 1, 1920. November 20, 1920, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case, anemic, highly septic, poorly nourished: present weight, 117 pounds (normal weight, 147 pounds). Persistent cough, with frequent expectoration of purulent blood tinged sputum. Examination of chest revealed marked deformity in the contour of the right chest wall due to collapsing operation. A sinus was present discharging pus, posterior scapular line at a level corresponding to eighth rib. Radiographs showed marked collapse of right lung with extensive thickening of pleura, right chest, from apex to base, and a long cavity formation extending from the second to the ninth rib lateral chest, with a capacity of 300 c. c. A large pleurobronchial fistula present and some regeneration and overlapping of rib stumps with osteomyelitic changes. Clinical laboratory examination: Wassermann, negative; sputum, negative for tubercle bacilli; white blood count, 12,300; red blood count, 3,480,000; urine showed heavy trace of albumin; culture from cavity showed heavy growth of hemolytic streptococcus. Blood pressure: Systolic, 148; diastolic, 90; pulse pressure, 58. Vital capacity reading, 1,500 c. c.

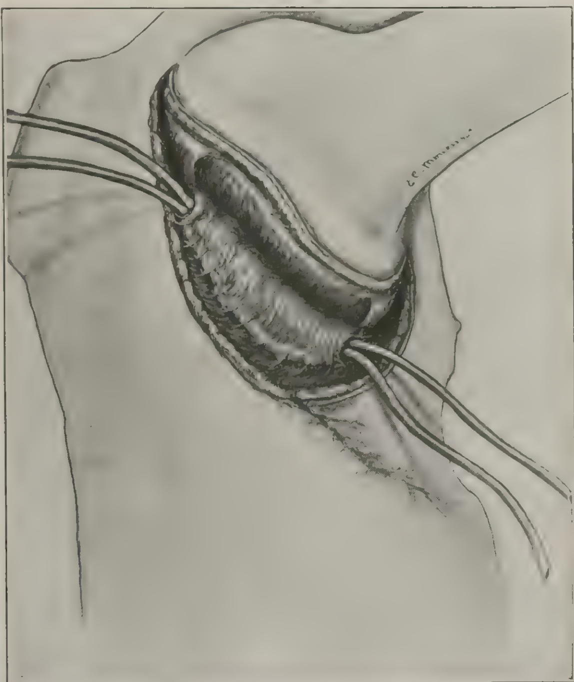

FIG. 86.—Case 8: The implantation of a muscle flap and the insertion of Carrel tubes, in the final closure of the wound.

November 29, 1920, operation; incision along old posterior scar line and extended by a U-like figure to anterior axillary line; entire cavity laid wide open; excision of all thickened pleura forming roof of cavity; skin and remaining muscle tissue saved for final closure. A fistula was noted, and the contiguous lung was mobilized. Preparation of cavity for active dakinization. January 20, 1921, operation: resection of 10 cm. of second, third, fourth, and fifth ribs in the posterior scapular line, right chest: implantation of a portion of the levator anguli scapulæ and erector spinæ muscles into the apex of cavity over pleurobronchial fistula; and closure of upper aspect of cavity with muscle and skin; cavity about sterile but active dakinization continued in lower aspect, which was left open. June 1, 1921, secondary closure of remaining wound; severed superficial muscles and skin brought in apposition and sutured; rubber tube and rubber dam drainage for 48 hours: multiple scarifications of skin to cause relaxation. July 12, 1921, operation; fistula still patent; small incision over posterior aspect in old scar line; lung mobilized about fistula; tract ligated by means of purse string, and another muscle flap implanted over area of closed fistula; wound packed and allowed to granulate. August 4, 1921, fistula still patent. Treated with 2 per cent alchoholic solution of gentian violet. The next day the communication was closed and remained closed. Wound granulated and was entirely healed on August 22, 1921. September 30, 1921, all cavity formation obliterated; lung well expanded and fistula remaining closed; patient gaining weight; general condition excellent. October 10, 1921, patient cured: present weight, 140 pounds; general condition excellent; vital capacity, 2,300 c. c. January 7, 1922, patient discharged as cured, after having been healed four months.

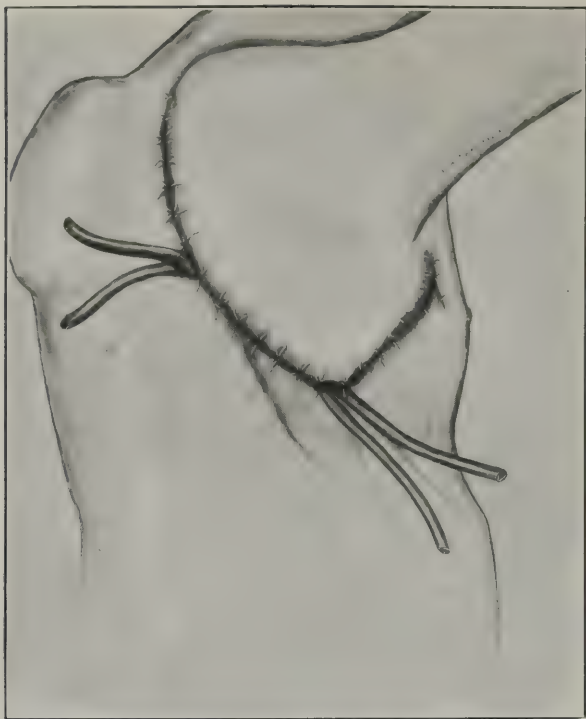

FIG. 87.—Case 8: The final skin suture.

FIG. 88.—Case 8: Final result.

Factors to be combated in this case were hemolytic streptococcus present; osteomyelitis; nephritis; pleurobronchial fistula; marked destruction of soft tissues, and deformity of chest wall.

Case 9.—H. T., age 24 years. January 22, 1919, developed influenza, followed by lobar pneumonia. January 26, 1919, complication, empyema, right pleural cavity, hemolytic streptococcus type. Later, developed otitis media, acute, catarrhal, right.

Prior to his admission to the empyema service, Walter Reed General Hospital, the patient had four operations with resection of the fourth to tenth ribs, inclusive. November 26, 1920, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory; general condition good; weight, 127 pounds (normal weight, 140 pounds). Examination of chest revealed a sinus, discharging pus, tenth interspace. Radiograph showed marked collapse of right chest wall with elongated, bismuth-filled cavity, approximately 16 cm. in length and 2.5 cm. at its widest portion, in the lateral portion of the chest just under the soft tissue covering, and extending from the tenth interspace to the fifth interspace, axillary line. There had been a resection of the fourth to tenth ribs, right side. Cavity showed smooth outlines with no evidence of diverticula or bronchial fistulæ. Clinical laboratory examination: Wassermann, negative; sputum, negative for tubercle bacilli; urine, negative; red blood count, 4,880,000; white blood count, 8,800; hemoglobin, 85 per cent. Blood pressure: Systolic, 120; diastolic, 80; pulse pressure, 40. Vital capacity reading not taken. Culture from cavity showed hemolytic streptococcus and staphylococcus aureus.

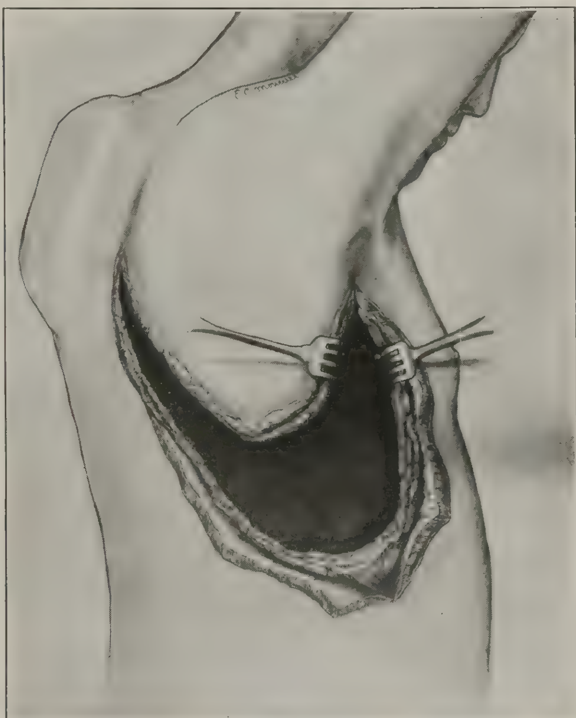

Fig. 89.—Case 9: The wound before muscle implantation and skin suture.

December 2, 1920, the first step of the fractional type operation was accomplished. The upper angle of the wound was attacked; ribs were resected and the old cavity was laid widely open at this point. Portions of the serratus magnus, the rhomboideus major and subcapularis muscles were implanted immediately into the cavity and sutured into place. The muscle bodies held and there was practically no sloughing following this operation. January 17, 1921, an incision at the lower angle of the old wound was made, the scar tissue was excised, and multiple sinuses were found leading in all directions. Sinuses were curetted and the wound left open. Patient placed on active dakinization. His condition seemed to be improving somewhat and it was decided to refrain from further operative procedure until there was a more definite improvement in the general condition. Capacity of cavity at this time was 200 c. c. April 5, 1921, resection of third to eighth ribs over anterior and lateral chest wall; cavity laid wide open. The apex of cavity was found to be obliterated following the muscle implantation at previous operation. July 6, 1921, cavity obliterated, but there was found evidence of osteomyelitis of the seventh, eighth, and ninth rib stumps: necrotic rib stumps resected. July 27, 1921, a sliding skin flap, with its subcutaneous fat, was twisted on its pedicle and transplanted into the lower angle of the wound, entirely closing this part of the cavity. A small part of the cavity remaining above this point could be obliterated by lung expansion on forced inspiration of the patient. September 19, 1921, sinus tract allowed to close, as patient had had seven consecutive daily sterile cultures. November 1, 1921, patient

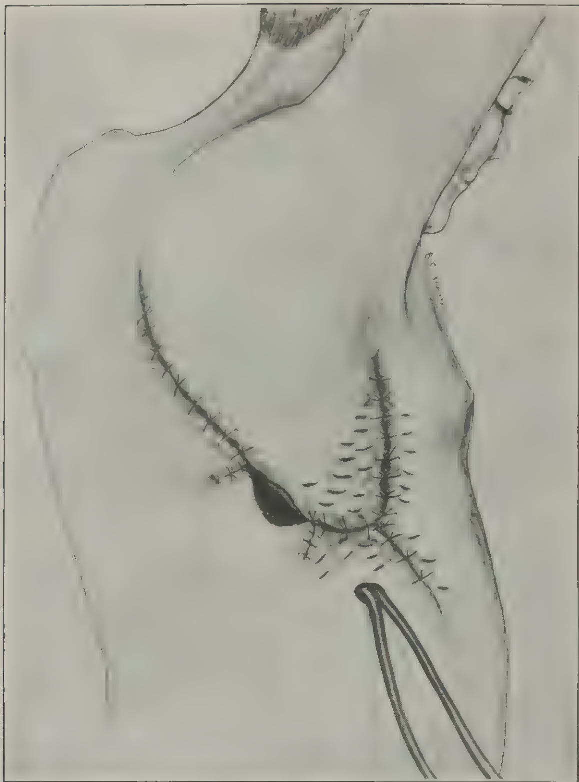

Fig. 90.—Case 9: Stages in the final closure.

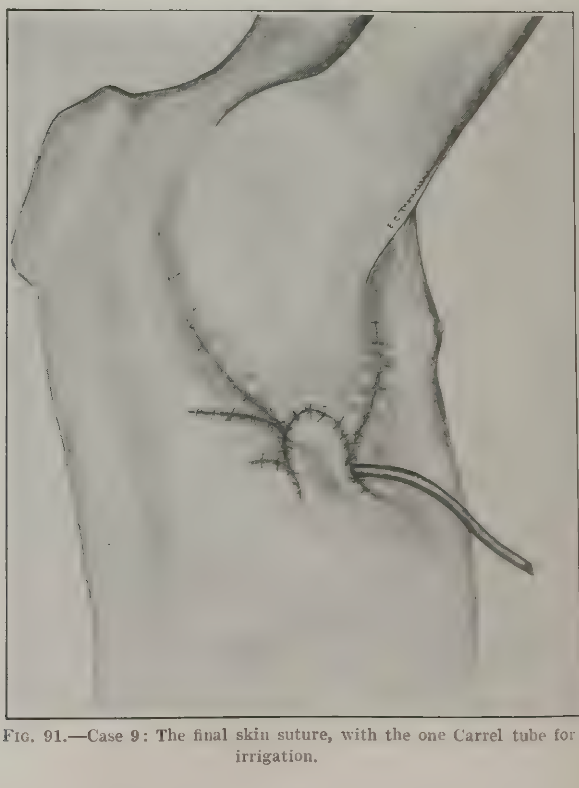

Fig. 91.—Case 9: The final skin suture, with the one Carrel tube for irrigation.

entirely healed. December 6, 1922, patient given a 30-day leave. January 6, 1922, returned from leave feeling fine, entirely healed; ready for discharge from hospital. January 31, 1922, patient discharged from hospital cured this date. X-ray picture taken prior to discharge showed rather marked collapse of chest wall, especially at the base, but no evidence of cavity.

Factors to be combated were hemolytic streptococcus and staphylococcus aureus present; osteomyelitis of terminal rib stumps.

Case 10.—J. S., age 19 years. February 2, 1921, developed pneumonia. February 15, 1921, complication, empyema, right pleural cavity, hemolytic streptococcus type. Aspirated six times. May 10, 1921, thoracotomy; trocar canula, with the introduction of a small catheter into cavity to institute drainage. At a subsequent date the opening was enlarged and by this method of procedure the patient was treated and irrigated once daily through two drainage tubes. July 3, 1921, admitted to the empyema service, Walter Reed General Hospital.

Fig. 92.—Case 9: The final result.

Condition on admission: Ambulatory case; poorly nourished; present weight, 133 pounds, (normal weight, 170 pounds). Examination of chest revealed a sinus discharging pus, 8th interspace, posterior axillary line, right chest. Radiographs showed marked collapse of right lung with some thickening of pleura right lateral chest, and a cavity formation extending from fifth to tenth rib, right chest; osteomyelitis, eighth rib, with sequestration. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 14,000; red blood count, 4,500,000; urine negative; culture from cavity showed hemolytic streptococci. Blood pressure: Systolic, 122; diastolic, 80; pulse pressure, 42. Vital capacity reading, 2,200 c. c.

July 8, 1921, operation; resection of 10 cm. of seventh and eighth ribs, posterior scapular line, right chest; cavity opened and about 50 c. c. of pus evacuated; cavity left open and preparation made for dakinization. September 8, 1921, operation; resection of 15 cm. fifth and sixth ribs; excision of thickened parietal pleura forming roof of cavity; discission of visceral pleura to allow lung expansion; skin inverted over muscle to preserve it for final closure; and preparation of cavity for the Carrel-Dakin technique for its sterilization. October 14, 1921, patient developed a pericarditis with effusion, accompanied by some myocardial involvement. Treatment by rest in bed with an ice cap to heart and the administration of morphine sulphate to control pain. October 20, 1921, patient improving; heart compensating for the overwork put upon it; effusion being absorbed; pain now controlled by ice cap. October 30, 1921, has taken care of his complete effusion in pericardium; heart normal in size and function. December 7, 1921, operation; plastic closure with portion of the latissimus dorsi and infraspinatus muscles implanted into small remnant of cavity that was not completely obliterated by lung expansion. Cavity sterile after seven daily consecutive cultures. Muscle and skin closure. December 20, 1921, patient completely healed; feeling well; appetite improved: gradual gain in weight: present weight, 142 pounds: heart showed no ill effects from pericarditis with effusion and there was no recurrence. January 30, 1922, patient healed: general condition excellent: weight 150 pounds; vital capacity reading, 3,500 c. c. May 16, 1922, patient discharged cured, after having been healed four and a half months.

Factors to be combated in this case were hemolytic streptococcus organism present; osteomyelitis with rib sequestration; pericarditis with effusion; primary drainage not dependent; cavity with a capacity of 350 c. c.

CASE 11.—R. C. W., age 30 years. Received gunshot wound, multiple, right chest and right leg October 6, 1918, in action. October 17, 1918, developed bronchopneumonia, traumatic, complicated by empyema. Aspirated twice. November 1,1918, thoracotomy with resection of one and one half inches tenth right rib. Lower wound allowed to close, but pus continued to drain through upper gunshot wound of chest. December 8, 1918, operation: thoracotomy with resection of part of eighth right rib. Dakinization attempted but not continued because of pleurobronchial fistula. April 8, 1919, operation; resection of part of seventh right rib, midaxillary line; tube drainage. July 5, 1919, resection of fifth, sixth, and seventh right ribs, midaxillary line; dakinization of wound followed. Drainage of wound continued; various antiseptic solutions being used, including gentian violet and bismuth paste. The cavity remained unobliterated and patient continued to drain pus. January 20, 1921, admitted to empyema service, Walter Reed General Hospital.

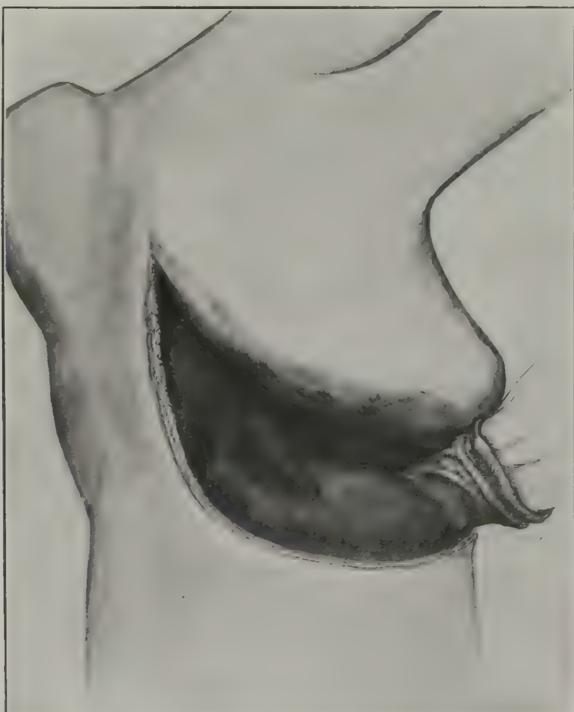

FIG. 93.—Case 11: The wound before muscle implantation and skin suture.

Condition on admission: General condition good. Examination of chest showed a sinus at level of the eighth rib, posterior axillary line, right chest. Sinus too small to admit tube drainage. Profuse discharge of thick pus on dressing. Radiograph showed a partial resection of parts of the fifth, sixth, seventh ribs anterior axillary line with resection of part of the ninth rib; a proliferation of the rib ends with union and cross union of previously resected ribs; cavity running posteriorly along the diaphragm, then upward to sixth rib posteriorly; cavity lying about the scapular line and about 6 cm. from the midline of spine; thickened pleura over entire right chest. Capacity of cavity about 500 c. c. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; urine negative; culture from cavity showed Gram-positive bacilli; no hemolytic streptococci; staphylococcus aureus present. Blood pressure: Systolic, 130; diastolic, 84. Vital capacity 2,400 c. c.

February 2, 1921, incision along old sinus tract; resection of sixth, seventh, eighth ribs over cavity; exposure of entire cavity with removal of parietal pleura and intercostal tissues; excision of sinus tract; discission of visceral pleura; cavity and wound packed with gauze; Carrel tubes placed and dakinization of cavity started.

The extent of the cavitation may be judged by the fact that at the daily dressing 42 Carrel tubes were laid in the cavity between the layers of gauze.

The cavity became clinically and bacteriologically clean within a short time, and its capacity diminshed with remarkable rapidity. At the time of the first plastic operation, April 1, the cavity had obliterated about 50 per cent. Frequent scarifications of the visceral pleura were made and this apparently hastened the obliterative process by permitting reexpansion of the underlying lung. April 1, 1921, removal of sequestrum of eighth rib. The cavity being sterile, a plastic closure of the upper angle of the cavity was done; contiguous muscle bodies at the lateral margin of the

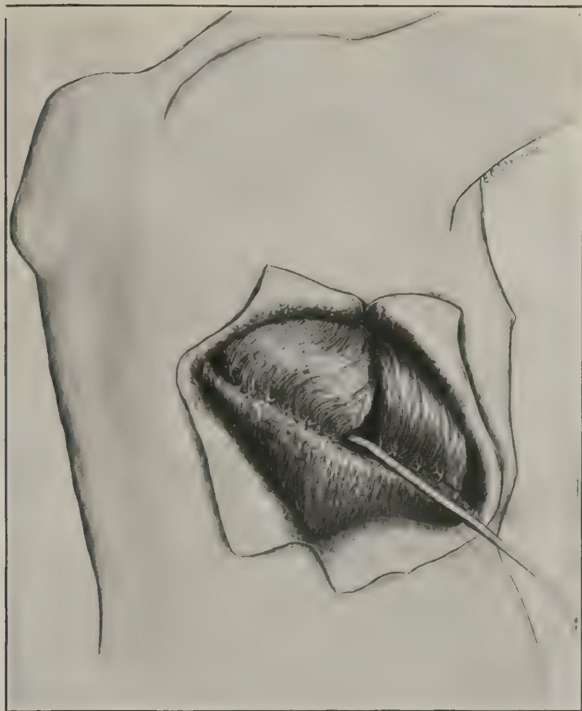

FIG. 94.—Case 11: The method used for muscle implantation.

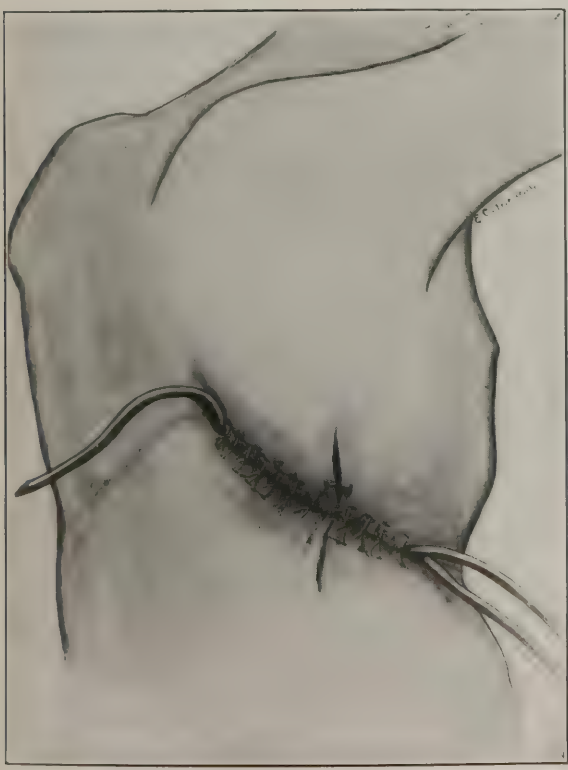

FIG. 95.—Case 11: The final suture of the skin.

wound were partially split and swung into the cavity and sutured in situ to the visceral pleura and sides of the wound. Following this implantation, there was slight superficial necrosis of the muscle implant, but the greater part of it became adherent and obliterated in the upper half of the wound and cavity. June 3, 1921, plastic closure of remaining cavity in its lower half. The upper half was now completely obliterated from the previous plastic operation. Plastic closure was done, as in the upper half, by the implantation of a large muscle plane. The skin and superficial tissues were brought into apposition and the wound was closed with rubber tissue drainage. The wound healed with the exception of a small sinus which persisted and continued to drain a slight amount of seropurulent exudate. July 12, 1921, incision along lower part of old scar, laying open a branched sinus tract. This tract was lined with infected granulations, but no rib involvement could be found. Tract was curetted and left open for Dakin treatment. The old cavity was found to be practically obliterated. September 16, 1921, operation; final plastic procedure to restore contour of chest wall; small gutter depression along lower part of old cavity closed by suture of opposing muscle bodies and skin. Recovery uneventful; wound completely healed in two weeks following last plastic operation. Patient granted several sick leaves and kept under observation until May 11, 1922, when he was discharged as cured, having been healed seven months.

Fig. 96.—Case 11: The final result after complete healing.

Terminal examination showed no cavity formation, either clinically or by radiograph. Fair lung expansion on the involved side. There was but slight deformity of the chest wall. General condition of patient excellent.

Factors to be combated were hemolytic streptococcus, staphylococcus aureus and pyocyaneus organisms present prior to admission; extremely large cavity; osteomyelitis with sequestration of rib stumps; marked lung collapse, with dense adhesions and greatly thickened visceral pleura.

Case 12.—A. M., age 22 years. March 22, 1919, developed pneumonia. March 27, 1919, complication, empyema, right pleural cavity, hemolytic streptococcus type. Aspirated five times April 14, 1919, operation; thoracotomy, resection of 10 cm. of eighth rib midaxillary line, right chest; 800 c. c. of pus evacuated and drainage instituted by double tube method: irrigations with Dakin's solution. November 10, 1919, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case, fairly well nourished but slightly anemic and under weight; weight on admission, 148 pounds (normal weight, 165 pounds); some edema and tenderness of joints of extremities; valvular heart disease, mitral insufficiency, in conjunction with myocarditis. Examination of chest: Sinus discharging pus eighth interspace, midaxillary line, right chest.

and a large cavity formation present. Radiographs showed marked collapse of right lung with extensive thickening of parietal pleura from apex to base; large cavity formation extending from fifth rib to base right posterior chest, the same being partially filled with pus, drainage not dependent, capacity of cavity about 400 c. c.; some displacement of heart to the right. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 9,250; red blood count, 4,350,000; urine negative; culture from cavity showed hemolytic streptococcus. Blood pressure: Systolic, 116; diastolic, 90; pulse pressure, 26. Vital capacity reading not taken.

Patient put on active dakinization, and a high caloric diet to improve general condition. Cultures were taken from the cavity daily to determine to what degree the Dakin's solution controlled the bacteria. Drainage not dependent, hence there was no improvement. Operative procedure was advised, but the patient refused operation and requested discharge from the service March 15, 1920, discharged from service, condition unchanged. December 6, 1920, readmitted to empyema service. Condition on readmission unchanged. Patient requested operation. December 15, 1920, operation: resection of 15 cm., sixth, seventh, eighth ribs, posterior axillary line, left chest; excision of thickened, parietal pleura forming roof of cavity; cavity laid wide open; discission of visceral pleura; skin inverted over muscle to preserve it for final closure; multiple scarification of skin to cause relaxation, and preparation of cavity for active dakinization. Patient developed profound shock following operation. All active measures to combat shock were instituted, but in spite of them the patient died two hours later.

Factors to be combated in this case were hemolytic streptococcus organism present; valvular heart disease, mitral insufficiency, in conjunction with myocarditis; osteomyelitis of seventh and eighth ribs; drainage not dependent.

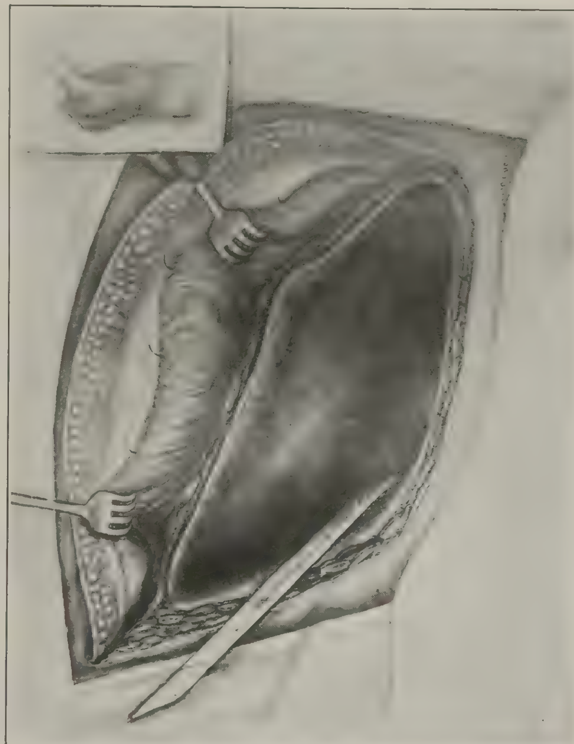

FIG. 97.—Case 13: A large cavity prepared for closure, showing the depth of the space to be obliterated.

CASE 13.—C. A. M., age 19 years. January 25, 1920, developed pneumonia. February 1, 1920, complication empyema, right pleural cavity, hemolytic streptococcus type. Aspirated five times. May 5, 1920, thoracotomy: resection of 5 cm. of eighth rib. Intermittent dakinization; drainage continued up to time of admission to Walter Reed General Hospital.

Condition on admission: General condition good; slight anemia; weight 200 pounds (normal). Examination of chest revealed sinus discharging pus at the level of the eighth rib, midaxillary line, right side. X-ray examination showed sinus at the level of the eighth rib leading into a cavity about 20 cm. in depth which extends backward and upward following the course of the seventh, eighth, and ninth ribs. Capacity of cavity 250 c. c. Clinical laboratory examination: Wassermann negative; urine negative; sputum negative for tubercle bacilli; red blood count, 4,500,000; white blood count, 5,200; hemoglobin 75 per cent; culture from cavity showed streptococcus hemolyticus. January 17, 1921, resections of 20 cm. of the eighth, ninth, and tenth ribs with excision of sinus tract leading to the spinal gutter. A second sinus tract was found leading to the posterior diaphragmatic sulcus. The original sinus and ribs surrounding it were not touched at this operation; cavity left wide open for active dakinization. March 14, 1921, second step of

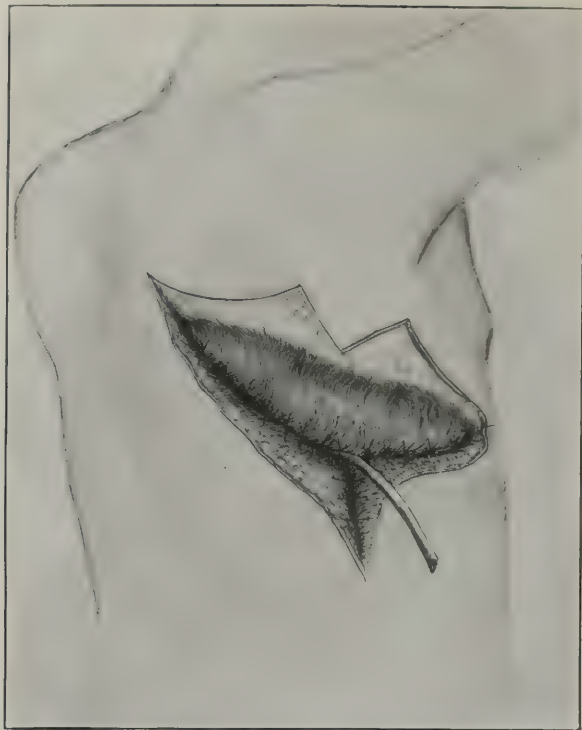

FIG. 98.—Case 13: Muscle implantation.

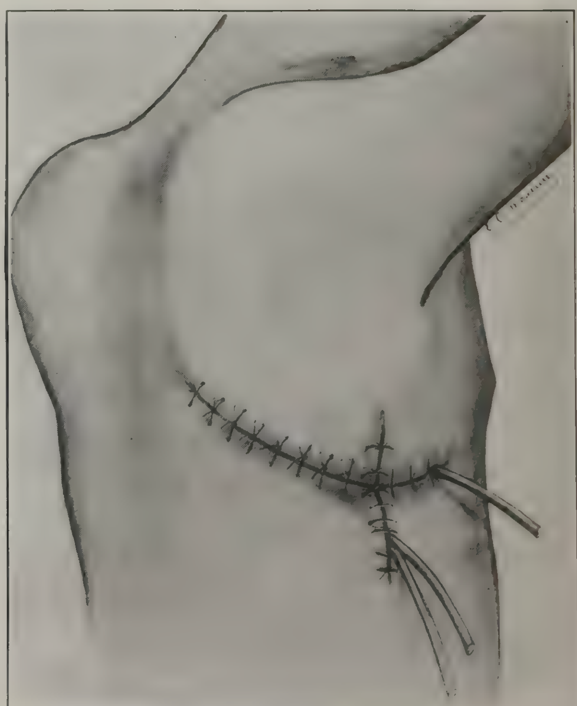

FIG. 99.—Case 13: Final suture of the skin flaps.

fractional operation done: excision of sinus tract with resection of about 10 cm. of ninth rib; cavity left open for dakinization. Following these operations, patient obliterated his cavity rapidly. May 12, 1921, the cavity at this time was less than one-fourth its original size; a plastic closure was done: implantation of part of the serratus magnus, to fill the remaining unobliterated portion, and sliding skin flaps were brought forward from each side and sutured. June 5, 1921, wound healed; general condition excellent. August 11, 1921, patient discharged, cured, after having been healed two months.

Factors to be combated in this case were hemolytic streptococcus organism present; osteomyelitis of terminal rib stumps; diverticula or accessory pockets.

Case 14.—P. B., age 23 years. January 30, 1921, developed pneumonia. February 25, 1921, complication, empyema, right pleural cavity, hemolytic streptococcus type. Aspirated twice. March 31, 1921, operation; thoracotomy; resection of 10 cm. of sixth rib, anterior axillary line, right chest; institution of drainage, and daily irrigations of cavity with Dakin's solution. Admitted June 9, 1921, to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; poorly nourished; anemic; weight, 117 pounds. Examination of chest revealed sinus discharging pus sixth interspace, anterior axillary line, right chest; pleurobronchial fistula present, and large cavity formation with a capacity of 450 c. c. Radiographs showed marked collapse of the right lung with extensive thickening of the lateral aspect of the right parietal pleura from apex to base, and a cavity formation extending from the second to the tenth rib. Drainage inadequate and not dependent. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 13,750; red blood count, 4,210,000; urine negative; culture from cavity showed hemolytic streptococcus. Blood pressure: Systolic, 128; diastolic, 78; pulse pressure, 50. Vital capacity reading, 1,800 c. c.

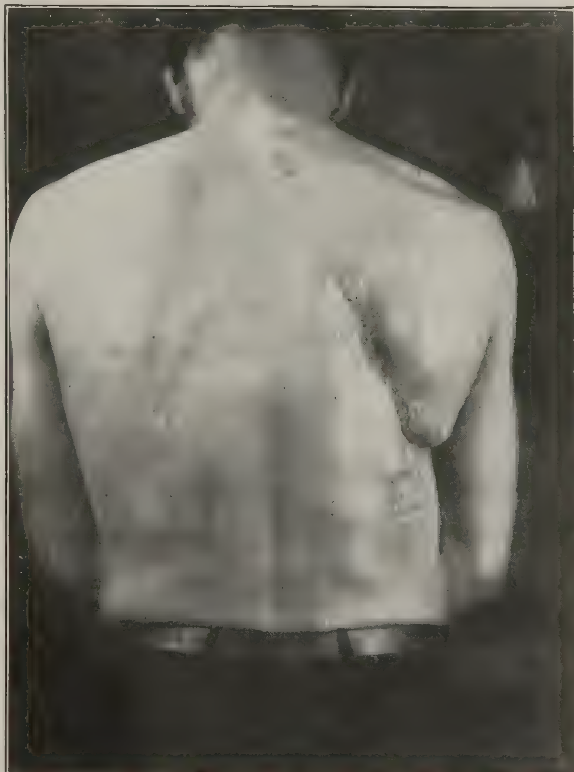

Fig. 100.—Case 13: Final result of closure.

June 28, 1921, operation; resection of 10 cm. of ninth and tenth ribs, midscapular line, right chest; cavity left open for active dakinization. October 13, 1921, resection of 10 cm. of sixth, seventh, and eighth ribs posterior axillary line, right chest; excision of thickened parietal pleura forming roof of cavity; skin inverted over muscles which were severed; cavity left open for active dakinization; fistula found closed since first operation, under treatment with gentian violet. December 2, 1921, operation; resection of 10 cm. of fifth, sixth, seventh, eighth, ninth and 5 cm. of the tenth and eleventh ribs, postscapular line, right chest, with the implantation of a portion of the latissimus dorsi into the apex of cavity, after discission of visceral pleura had been done. Partial closure of muscle and skin over upper aspect of cavity; lower portion left open for active dakinization. January 25, 1922, secondary closure of skin and muscle, lower portion of cavity; rubber dam drainage, with Carrel tube in most dependent portion. February 8, 1922, patient developed myocarditis, and appropriate treatment for this condition was instituted. Empyema closed; lung well expanded; all cavity formation obliterated. May 1, 1922, patient improving;

myocarditis clearing up; empyema entirely healed; and general condition good. June 5, 1922, patient discharged from hospital cured. Weight on admission, 117 pounds; weight on discharge, 137 pounds. Condition good; all cavity formation obliterated; lung well expanded; vital capacity reading, 2,900 c.c.; myocarditis greatly improved. Empyema completely cured; discharged cured June 5, 1922.

Factors to be combated were hemolytic streptococcus organism present; osteomyelitis with rib sequestration; secondary cavity formation; pleurobronchial fistula present; myocarditis, chronic.

Case 15.—J. C., age 28 years. September 15, 1918, developed influenza and pneumonia. October 10, 1918, complication, empyema, left pleural cavity, hemolytic streptococcus type. Aspirated twice. October 16, 1918; operation; thoracotomy; resection of a portion of the sixth rib, midaxillary line; institution of drainage; and the irrigation of the cavity with Dakin's solution. November 17, 1918, a secondary drainage operation was done, with removal of a portion of the seventh rib. August 22, 1919, decortication operation with resection of portion of fifth, sixth, seventh, eighth, ninth, and tenth ribs; and drainage of the lower aspect of the cavity. September 17, 1920, resection of an additional portion of eighth rib stump and the resection of 5 cm. of the third and fourth ribs, posterior scapular line, left chest. Following this the patient would heal and break down, with a persistent expectoration of blood from pleuropulmonary communications. February 10, 1921, admitted to empyema service, Walter Reed General Hospital.

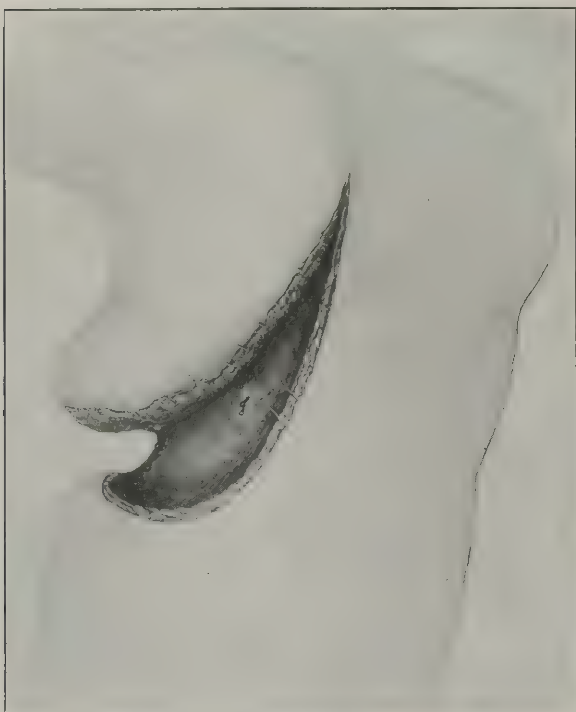

Fig. 101.—Case 15: Illustrating method of partial closure of bronchial fistula.

Condition on admission: Ambulatory case; anemic; poorly nourished; present weight 127 pounds (normal weight 145 pounds); extremely toxic with renal complications, chronic interstitial nephritis. Examination of chest revealed great deformity in the contour of the left lateral chest with an "ax chop" appearance and a sinus discharging pus, midaxillary line. Radiographs showed marked collapse of the left lung with extensive thickening of the pleura from apex to base, and a cavity formation extending from the third to the eighth rib, left lateral chest, having a capacity of 250 c.c. A pleurobronchial fistula was present and osteomyelitis of resected rib stumps noted. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 13,560; red blood count, 3,970,000; urine showed heavy trace of albumin and hyaline and granular casts; culture from cavity showed hemolytic streptococcus. Blood pressure: Systolic, 144; diastolic, 86; pulse pressure, 58. Vital capacity reading, 1,600 c.c.

February 18, 1921, operation; incision along line of old scar; cavity laid wide open; necrotic rib stumps removed; excision of thickened parietal pleura forming roof of cavity; discission of visceral pleura to allow lung expansion; all skin and muscles preserved for final closure and preparation of cavity for active dakinization. June 9, 1921, operation; partial closure of the cavity with the suturing of the fistula present, and the implantation of a portion of the latissimus dorsi muscle over it; upper aspect of cavity closed with muscle and skin; lower portion left open for active dakinization. September 13, 1921, incision of sinus tract leading posteriorly and upward; communicating with main cavity; the tract left wide open for active dakinization. October 1, 1921, cavity found to be sterile after seven consecutive daily cultures. October 5, 1921, resection

of 5 cm. of regenerated fifth and sixth ribs, posterior scapular line; discission of visceral pleura: fistula found closed. Plastic flap of the subscapularis muscle was implanted in upper aspect of remaining cavity; superficial muscles brought in apposition and sutured. Skin closed with figure-of-eight silkworm gut; multiple scarifications of skin to cause relaxation; lower aspect of wound left open to granulate. November 30, 1921, patient entirely healed and gaining weight; X-ray examination showed all cavity formation obliterated; general condition excellent; urine negative for albumin and casts. Weight on admission, 127 pounds; present weight, 148 pounds. Vital capacity reading, 2,400 c. c. March 1, 1922, patient's general condition excellent; appetite good. April 4, 1922, patient entirely healed and discharged from hospital, cured.

Factors to be combated were hemolytic streptococcus present; pleurobronchial fistula present; osteomyelitis of rib stumps; secondary cavity formation; chronic interstitial nephritis; marked collapse of left chest wall due to previous operative procedure.

Case 16.—R. R., age 24 years. February 1, 1921, developed pneumonia. March 25, 1921, complication, empyema, left cavity, hemolytic streptococcus type. Aspirated three times. April 25, 1921, operation; thoracotomy; resection of 10 cm. of seventh rib anterior axillary line, left chest; institution of drainage; cavity irrigated with Dakin's solution. June 9, 1921, admitted to empyema service, Walter Reed General Hospital.

Fig. 102.—Case 15: Muscle implantation.

Condition on admission: Ambulatory case, fairly well nourished, but considerably underweight; weight on admission, 118 pounds (normal weight, 160 pounds). Examination of chest revealed sinus discharging pus, seventh interspace, anterior axillary line, left chest; and a cavity formation with a capacity of 700 c. c. Pleurobronchial fistula present and drainage not dependent. Radiographs showed a partial collapse of left lung with considerable thickening of the pleura, and a cavity formation extending from fourth rib to base, and posterior to the sinus leading to the cavity. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 9,450; red blood count, 5,010,000; urine negative; culture from cavity showed hemolytic streptococcus and staphylococcus aureus. Blood pressure: Systolic, 126; diastolic, 80; pulse pressure, 46. Vital capacity reading, 2,100 c.c.

June 28, 1921, operation; resection of 10 cm. of ninth rib, posterior axillary line; and the institution of dependent drainage; cavity left open for active dakinization. October 13, 1921, operation; resection of 20 cm. of sixth, seventh, and eighth ribs, posterior axillary line, left chest; excision of thickened parietal pleura forming roof of cavity; skin inverted over muscles that were severed and sutured over rib stumps; preparation of cavity for active dakinization. December 29, 1921, operation: resection of 10 cm. of seventh and eighth ribs, midaxillary line; removal of thickened parietal pleura: mobilization of lung about fistula and closure of posterior aspect of cavity, using muscle and skin. February 23, 1922, operation; resection of 10 cm. of posterior stump of seventh rib which showed osteomyelitis with sequestration; cavity left open for dakinization. March 8, 1922, operation: resection of 15 cm. of anterior stump seventh rib which showed osteomyelitis with sequestration. This portion of rib was regenerated bone which had become infected. Entire cavity

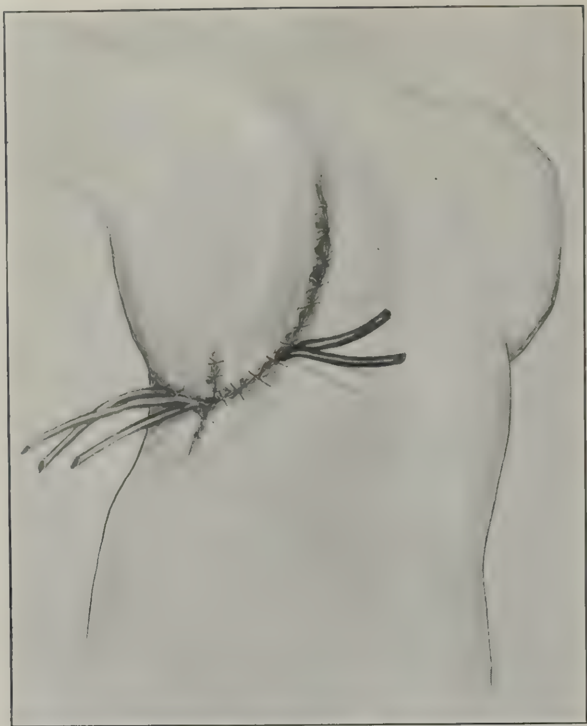

Fig. 103.—Case 15: Final skin suture.

Fig. 104.—Case 15: End result.

left open for active dakinization. April 6, 1922, plastic closure of muscle and skin, with implantation of a portion of latissimus dorsi and subscapularis muscles into apex of cavity to obliterate multiple fistulæ; superficial muscles and skin brought into apposition and sutured by means of silkworm gut; rubber dam and one tube drainage for 48 hours; multiple scarification of skin to cause relaxation. May 15, 1922, patient entirely healed and doing well. June 25, 1922, patient entirely healed; all fistulæ closed; all cavity formation obliterated; lung well expanded; general condition excellent; vital capacity reading, 3,300 c. c.; weight, 152 pounds.

Factors to be combated in this case were hemolytic streptococcus and staphylococcus aureus present; osteomyelitis with rib sequestration; pleurobronchial fistulæ present; secondary cavity and diverticula; partial heart block.

CASE 17.—W. G., age 30 years. October 1, 1918, developed influenza and pneumonia. October 13, 1918, complication, empyema, right pleural cavity, hemolytic streptococcus type; aspirated once. October 15, 1918, operation; thoracotomy, eighth interspace, posterior axillary line, with the institution of drainage. December 23, 1918, thoracotomy; resection of a portion of the eighth rib, posterior axillary line; better drainage instituted. September 24, 1919, decortication operation with resection of a portion of fifth, sixth, seventh, eighth, ninth, and tenth ribs; complete decortication of visceral pleura; wound closed with dependent drainage. Following this operation, there was a slough of the soft tissue along posterior incision and a protrusion of rib stumps into opening with exposure of nerve ending from posterior horn cells. Dressings were very difficult at this time; Dakin's solution was tried but was discontinued because of a bronchial fistula, which caused patient to strangle; iodoform emulsion used in dressings; mercuracrome also tried. Patient exposed to sun rays and to various forms of tub baths. Treated by these various methods until September 23, 1920. September 24, 1920, admitted to empyema service, Walter Reed General Hospital.


FIG. 105.—Case 17: The wound after removal of the fourth to eleventh ribs, exposed and necrosed on admission.

Condition of admission: Litter case; anemic; highly septic; poorly nourished; present weight 96 pounds (normal weight, 140 pounds). General condition extremely poor. Examination of chest revealed large open wound, posterior scapular line, with retraction of soft tissues in this area, and exposed necrotic posterior rib stumps fifth, sixth, and seventh, with much unhealthy granulation tissue about them; posterior horn cells exposed, and patient extremely sensitive over this area. This open wound communicated with cavity formation which had a capacity of 650 c. c. Radiographs showed almost total collapse of right lung with extensive thickening of the pleura, right chest, from apex to base and a large cavity formation extending from first to tenth rib, lateral chest. A large pleurobronchial fistula noted; marked osteomyelitis of resected rib stumps. A cold abscess was present over right sacroiliac region. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 9,750; red blood count, 3,750,000; urine negative; culture from cavity showed heavy growth of hemolytic streptococcus. Blood pressure: Systolic, 108; diastolic, 76; pulse pressure, 32. Vital capacity reading, 1,300 c. c.

This patient's general condition was so poor at time of admission that it was necessary to build him up before he could withstand even a fractional type of operation. This was accomplished by stomachics and a high-caloric diet; eggnogs at least three times daily. Cold abscess was injected with iodoform emulsion and strapped. Cavity given active dakinization

Fig. 106.—Case 17: Lateral view of final result.

Fig. 107.—Case 17: Anterior view of final result, showing condition after shortening clavicle to bring scapula closer to lung so as to aid in obliteration of the cavity.

October 29, 1920, operation; resection of necrotic rib stumps, fourth, fifth, sixth, and removal of unhealthy granulations, with mobilization of lung about fistula; deep alcohol injection of nerves from posterior horn cells; cavity left open for active dakinization. February 4, 1921, resection of 15 cm. of third, fourth, fifth, sixth ribs, anterior chest, 1 inch from costochrondral junction; excision of thickened parietal pleura and discission of visceral pleura to allow lung expansion; skin inserted over severed superficial muscles and fixed; cavity left open for the continuation of active dakinization. April 13, 1921, operation; resection of a portion of ninth and tenth ribs, posterior axillary line; resection of regenerated portion of sixth and seventh ribs anterior axillary line; dakinization continued. June 21, 1921, operation; resection of 10 cm. of second, third, and fourth ribs posterior scapular line, right chest; excision of thickened parietal pleura and exposure of apex of cavity; mobilization of lung about fistula; dakinization continued; all muscle and skin saved and tucked beneath scapula. Following this operation, the angle of the scapula made pressure on underlying lung structure, hence patient was dressed with a thin steel rib 2 inches wide and so constructed as to fit the general contour of the chest. This band was well padded and passed beneath the angle of the scapula and was fixed in place by straps over shoulders and tape across terminal end of steel rib on unaffected side of chest. This held the angle of the scapula away from the underlying lung and did not interfere with active dakinization of the cavity. July 19, 1921, closure of bronchial fistula by means of mattress suture and mobilization of lung about the fistula; dakinization continued. September 13, 1921, decortication of visceral plcura about fistula that still remained patent; purse-string ligation of fistula; dakinization continued. October 1, 1921, fistula still patent, although considerably smaller; a 2 per cent alcoholic solution of gentian violet applied and the following day fistula was closed. This application was repeated to keep mechanical plug in fistula until granulations had obliterated tract. November 15, 1921, the remaining cavity formation in this case consisted of a pyramidal space, with its base in the upper aspect of the right chest between the clavicle anteriorly, first rib internally and superiorly and the scapula posteriorly, and with its apex downward and in the midaxillary line. It was necessary to devise some method to obliterate this space as a maximum amount of lung expansion had been obtained by discission of the visceral pleura. December 1, 1921, shortening of clavicle to obliterate aforesaid space; clavicle shortened 2 inches and fragments morticed and wired in apposition; muscle and skin closed over space. December 28, 1921, operation; resection of regenerated third and fourth ribs, anterior axillary line, to allow scapula free excursion of motion (since clavicle had been shortened) and to completely obliterate the space. Portions of the pectoralis major and subscapularis muscles were implanted into apex of space to act as a buffer between the scapula and the underlying lung structures. Following these operations, the angle of the scapula was reflected backward and outward, therefore the device to elevate scapula from underlying lung tissue was no longer required. Pleurobronchial fistula remained closed, and cavity practically sterile. February 2, 1922, plastic closure of anterior aspect of wound with muscle and skin; closure of the upper posterior aspect with muscle and skin using silkworm gut sutures; rubber dam drainage for 24 hours; multiple scarifications of skin to cause relaxation along the suture line and to prevent slough; lower aspect of cavity left open for active dakinization. February 27, 1922, further secondary closure and re-suture of small areas along posterior aspect left open for drainage; multiple scarifications of skin to cause relaxation of suture line; lowermost aspect of wound still left open for dakinization. March 23, 1922, additional closure of posterior aspect of wound, muscle and skin, leaving only a small area at lowermost aspect to heal by granulation, this area being so superficial that plastic flap did not seem necessary. March 30, 1922, all but healed; general condition good; has begun to take on weight; lung expanded; all cavity formation obliterated. June 12, 1922, sliding-flap graft of skin and subcutaneous tissue into unhealed area; plastic closure of remaining structures; multiple scarification of skin to cause relaxation; rubber dam drainage for 48 hours. June 26, 1922, patient all but healed.

Factors to be combated in this case were hemolytic streptococcus organism present; osteomyelitis; pleurobronchial fistula; cold abscess, and condition of tissues caused tuberculosis to be reckoned with; mechanics necessary to obliterate cavity; patient's general debilitated condition, with faulty metabolism; patient able to withstand only a few minutes on table.

Case 18.—J. K., age 25 years. July 18, 1918, received penetrating gunshot wound right chest, machine gun bullet, in action. July 20, 1918, débridement operation. Was aspirated six times, a serosanguineous fluid being withdrawn. December 13, 1918, operation: exploratory thoracotomy seventh and eighth ribs, midaxillary line; bullet removed and wound closed. Numerous aspirations followed. January 1, 1919, developed empyema, hemolytic streptococcus type. January 15, 1919, area of previous thoracotomy reopened and drainage instituted with irrigation by Dakin's solution. Treated by this method and reopened a number of times. June 4, 1921, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; fairly well nourished but showng some anemia; present weight, 140 pounds (normal weight 150 pounds); fingers clubbed; some edema of extremities. Examination of chest revealed sinus discharging pus, seventh interspace, midaxillary line, right chest, with a large cavity formation partially filled with pus. Radiographs showed marked collapse of right lung with extensive thickening of the parietal pleura, right lateral chest, from apex to base; a cavity formation extending from the second to tenth ribs with a capacity of 600 c. c.; and osteomyelitis of rib stumps which had been previously resected. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 12,600; red blood count, 4,560,000; urine negative; culture from cavity showed hemolytic streptococci. Blood pressure: Systolic, 115; diastolic, 70; pulse pressure, 45. Vital capacity reading, 1,600 c. c. June 9, 1921, resection of 10 cm. of sixth, seventh, and eighth ribs, midaxillary line, right chest; excision of thickened parietal pleura forming roof of cavity; skin inverted over muscles that were severed and the muscles fixed over rib stumps, to prevent retraction and preserve them for the final closure; cavity left wide open for active dakinization. June 30, 1921, resection of 10 cm. of sixth, seventh, eighth, and ninth ribs, posterior scapular line; excision of thickened parietal pleura en masse; skin fixed over severed muscles; cavity left wide open for active dakinization. July 25, 1921, resection of 10 cm. of fourth and fifth ribs, posterior scapular line; cavity left wide open and active dakinization continued. November 2, 1921, resection of 15 cm. of sixth, seventh, eighth and ninth ribs, anterior axillary line; removal of roof of cavity; active dakinization continued. October 3, 1921, resection of 20 cm. of eighth, ninth, and tenth ribs; removal of roof of cavity; discission of visceral pleura and dakinization continued. February 27, 1922, resection of 20 cm. of fourth and fifth ribs, anterior axillary line; removal of necrosed sixth and seventh rib-stumps, same line; and resection of 10 cm. of third rib, posterior scapular line; active dakinization continued. March 9, 1922, secondary closure of upper aspect of cavity, muscle and skin, with the implantation of a portion of the infraspinatus muscle into apex of cavity, severed superficial muscles, which had been saved, brought in apposition and sutured; excision of all scar formation; and skin closed by silkworm gut suture; rubber dam drainage along suture line; discission of entire visceral pleura before closure; and lower aspect of cavity left open for active dakinization. May 11,

Fig. 108.—Case 18: First stage in closure of the wound.

1922, partial plastic closure of empyema cavity, right chest, using muscle and skin, with implantation of superficial muscle body into remaining space after maximum lung expansion had been obtained; skin and muscle brought in apposition by means of silkworm gut; multiple scarification of skin to cause relaxation; and rubber dam drainage for 48 hours. June 28, 1922, plastic closure of posterior aspect of cavity with muscle and skin; muscle and skin brought in apposition and sutured by means of silkworm gut; rubber dam drainage for 48 hours; multiple scarification of skin to cause relaxation.

Factors to be combated were hemolytic streptococci present; osteomyelitis of ribs; diverticula or secondary cavities; constitutional psychopathic state; myocarditis, chronic.

Case 19.—C. N., age 35 years. February 8, 1921, developed pneumonia. February 19, 1921, complication, empyema, right pleural cavity, hemolytic streptococcus type. Aspirated four times. March 6, 1921, operation; incision and drainage of empyema cavity. March 17, 1921, thoracotomy; resection of 10 cm. of seventh rib, midaxillary line, right chest; and better drainage instituted. May 30, 1921, incision over old scar and the resection of an additional 10 cm. of seventh rib, anterior aspect; and drainage reestablished. July 3, 1921, admitted to empyema service, Walter Reed General Hospital.

Fig. 109.—Case 18: Second stage in the closure of the wound.

Condition on admission: Ambulatory case; poorly nourished; present weight, 118 pounds (normal weight, 165 pounds). Examination of chest revealed sinus discharging pus seventh interspace, midaxillary line, right chest; pleurobronchial fistula present; and drainage not dependent. Radiographs showed a partial collapse of the right lung with some thickening of the pleura, right lateral chest, and a cavity formation extending from the fourth to the ninth rib and posterior to the sinus draining it. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 13,700; red blood count, 3,990,000; urine negative; culture from cavity showed heavy growth of hemolytic streptococcus. Blood pressure: Systolic, 128; diastolic, 88; pulse pressure, 40. Vital capacity reading 2,300 c. c. July 7, 1921, operation; resection of seventh and eighth ribs, posterior axillary line, right chest; roof of cavity removed; two pleurobronchial fistulæ exposed; skin inverted over muscle to preserve it for final closure and to render dressings less painful; cavity left open for active dakinization. July 25, 1921, resection of 15 cm. of the sixth rib, midaxillary line, rib stumps of the previously resected ribs removed; cavity widely exposed; discission of the visceral pleura; lung mobilized about fistula; cavity left open for active dakinization. September 29, 1921, excision of scar and mobilization of lung about fistula; cavity left open for dakinization. December 15, 1921, cavity apparently sterile after seven consecutive daily cultures; pleuropulmonary communications, closed. December 16, 1921, plastic closure; implantation of a part of the latissimus dorsi into that portion of the cavity which was not completely obliterated. The severed superficial muscles were brought in apposition, skin closed by figure-of-eight silkworm gut suture; and rubber dam drainage instituted. January 1, 1922,

FIG. 110.—Case 18: Third stage in the closure of the wound.

FIG. 111.—Case 18: Posterior view of the wound, with healing practically complete.

patient entirely healed; general condition excellent; increase in weight since first operation; X ray showed total obliteration of all cavity formation and the lung well expanded. February 1, 1922, general condition excellent; weight on admission to this hospital 118 pounds, present weight, 165 pounds; vital capacity reading, 3,400 c. c.

Factors to be combated in this case were hemolytic streptococcus organism present; osteomyelitis with rib sequestration; two pleurobronchial fistulæ; primary drainage not dependent.

CASE 20.—H. S. J., aged 26 years. January 10, 1918, developed influenza and pneumonia. January 20, 1918, complication, empyema, right pleural cavity, hemolytic streptococcus type. Aspirated twice. January 24, 1918, thoracotomy; resection of portion of seventh rib, midaxillary line, with the institution of drainage for five months without irrigation, followed by irrigation with Dakin's solution for two weeks. June 19, 1918, additional rib resection; institution of better drainage. November 11, 1918, resection of portion of eighth and ninth ribs to allow better drainage; and daily irrigation with Dakin's solution. February 19, 1920, resection of sixth, seventh, eighth, and ninth ribs, right chest, midaxillary line; partial decortication of visceral pleura; removal of portion of thickened parietal pleura; cavity closed; rubber tube drainage. June 3, 1920, cavity reopened and further decortication was done in an attempt to obliterate cavity, lower aspect being left open for dakinization. November 10, 1920, admitted to empyema service, Walter Reed General Hospital.

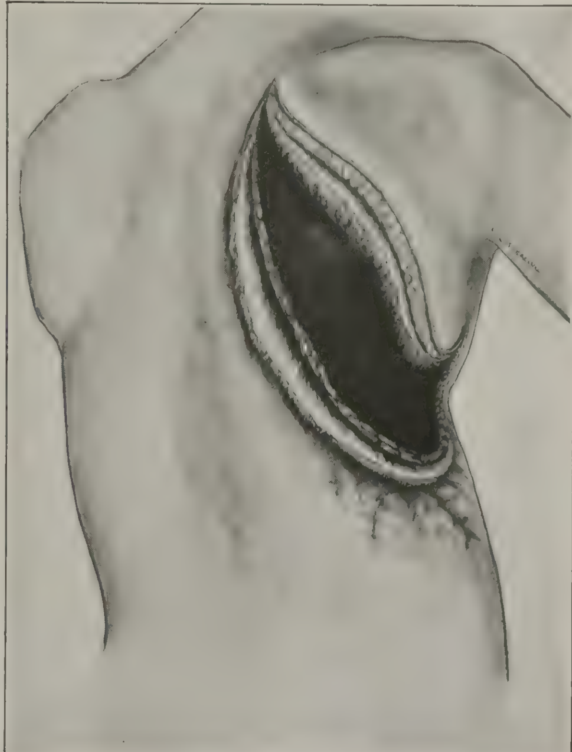

FIG. 112.—Case 20: Persistent bronchial fistula in a wound otherwise ready for closure.

Condition on admission; Ambulatory case; anemic; highly septic; poorly nourished; present weight, 111 pounds (normal weight, 145 pounds), fingers clubbed; extremities edematous. Examination of chest revealed sinus discharging pus, posterior axillary line; marked deformity of contour of right chest due to previous operations. Radiograph showed marked collapse of right lung with extensive thickening of pleura from apex to base, and a bismuth-filled cavity extending from second rib to midaxillary line, with multiple diverticula draining into main cavity. Capacity of cavity, 200 c. c. Pleurobronchial fistula present, the communication being almost direct to the hilus of the lung. Osteomyelitis of rib stumps present. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 12,600; red blood count, 3,750,000; urine showed trace of albumin; culture from cavity showed heavy growth of hemolytic streptococcus. Blood pressure: Systolic, 110; diastolic, 80; pulse pressure, 30. Vital capacity reading, 1,500 c. c.

November 17, 1920, resection of fifth, sixth, seventh, and eighth ribs, posterior scapular line, right chest; excision of thickened parietal pleura and scar tissue; cavity laid wide open; multiple diverticula noted, their roofs being excised; preparation of cavity for active dakinization. December 6, 1920, resection of 10 cm. of third, fourth, and fifth ribs; cavity laid wide open; dakinization continued. January 12, 1921, excision of another diverticulum, or sinus tract, draining into

FIG. 113.—Case 20: The wound immediately after closure.

FIG. 114.—Case 20: Final result.

main cavity; dakinization continued. March 31, 1921, excision of old scar, lower aspect of cavity, and an additional portion of the eighth rib resected which had become osteomyelitic. May 17, 1921, incision, anterior axillary line; resection of parts of fifth, sixth, and seventh ribs; three additional sinus tracts found and excised; active dakinization continued. June 23, 1921, resection of third and fourth ribs, anterior axillary line; removal of roof cavity; dakinization continued; discission of visceral pleura and mobilization of lung about bronchial fistula. July 27, 1921, incision along old posterior scar; apex of cavity exposed posteriorly; dakinization continued. October 3, 1921, resection of 5 cm. of third rib, posterior scapular line; excision of thickened parietal pleura; discission of visceral pleura; mobilization of lung about bronchial fistula; dakinization continued. January 12, 1922, resection of regenerated stumps of third, fourth, and fifth ribs, anterior to posterior axillary line; portion of subscapularis muscle implanted over fistula after lung had been mobilized about fistula; anterior aspect of cavity closed; superficial muscle brought in apposition and sutured skin closed by means of silkworm gut; multiple scarification of skin to cause relaxation; posterior aspect of cavity left open for dakinization. March 3, 1922, secondary closure with implantation of portion of latissimus dorsi into remaining cavity which was not obliterated by lung expansion, fistula having remained closed following last operation and cavity sterile; superficial muscles brought in apposition and sutured; skin closed by means of silkworm gut; rubber dam drainage for 24 hours; multiple scarification of skin to cause relaxation. April 1, 1922, patient improving, but had small area of tenth rib showing osteomyelitis, requiring resection at a future date. May 5, 1922, operation; resection of 10 cm. of tenth rib, posterior axillary line, right chest, and excision of sinus tract leading down to it; entire area left wide open for active dakinization. June 26, 1922, patient entirely healed; fistula closed; all cavity formation obliterated; lung well expanded; general condition excellent; weight on admission, 111 pounds; present weight, 122 pounds; vital capacity reading, 2,200 c. c.

FIG. 115.—Case 21: A stage in the healing of the wound.

Factors to be combated in this case were hemolytic streptococcus infection; osteomyelitis of rib stumps; secondary cavities and diverticula; pleurobronchial fistula; marked bridging and overlapping of regenerated rib formation.

CASE 21.—R. H. S., age 30 years. November 1, 1918, in action, received a gunshot wound, left chest, penetrating sixth interspace, nipple line. November 4, 1918, developed influenza, which was complicated by pneumonia November 10, 1918, and by empyema, left pleural cavity, hemolytic streptococcus type, November 17, 1918. Aspirated four times. November 25, 1918, operation; thoracotomy; resection of a portion of the eighth rib midscapular line, with the institution of drainage. March 22, 1919, discharged from the service, still draining; had been reopened 12 times for the institution of drainage. January 26, 1922, admitted to the empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; fairly well nourished but considerably underweight normal weight, 165 pounds; present weight, 145 pounds. Examination of chest: Sinus discharging pus, eighth interspace, midscapular line, left chest; drainage not dependent. Radiographs showed marked collapse of left lung; a cavity formation, with a capacity of 500 c. c. extending from the fourth to the ninth rib; heart considerably displaced to the right; and marked thickening of the parietal pleura, left lateral chest, from second rib to base. Clinical laboratory examination: Wassermann, negative; sputum, negative for tubercle bacilli; white blood count, 8,050; red blood count, 4,810,000; urine, negative; culture from cavity showed hemolytic streptococcus and staphylococcus aureus. Blood pressure: Systolic, 106; diastolic, 74; pulse pressure, 32. Vital capacity reading, 2,000 c. c.

January 31, 1922, operation: resection of 15 cm. seventh, eighth, and ninth ribs, midscapular line, left chest; excision of thickened parietal pleura forming roof of cavity; skin inverted over severed muscles and fixed over resected rib stumps to render dressings less painful and preserve structures for future closure; multiple scarifications of skin to cause relaxation; preparation of cavity for active dakinization. February 13, 1922, operation; resection of 15 cm. of fourth, fifth; and sixth ribs, posterior axillary line, left chest; removal of thickened parietal pleura forming roof of cavity; discission of visceral pleura to allow lung expansion; skin inverted over muscles that were cut and preserved for future closure; entire cavity left open for active dakinization. March 8,1922, cavity one-fourth its original size and the lung still expanding; bacterial examination showed only a few colonies of staphylococcus aureus. April 5, 1922, plastic closure muscle and skin, with the implantation of a portion of the latissimus dorsi into remaining space after maximum lung expansion had been obtained; skin and superficial muscles brought into apposition and sutured with silkworm gut; scarification of skin to cause relaxation; rubber dam and tube drainage for 24 hours. May 1, 1922, patient entirely healed; general condition excellent; increased weight since first operation; lung well expanded; all cavity formation obliterated. June 12, 1922, healed· physical condition excellent: weight 165 pounds; vital capacity, 3,400 c. c. Discharged, cured, June 12, 1922.

Fig. 116.—Case 21: A posterolateral view of the wound after complete healing.

Factors to be combated in this case were hemolytic streptococcus organism present; osteomyelitis with rib sequestration; secondary cavity.

Case 22.—W. L., aged 21 years. February 4, 1921, developed pneumonia. March 1, 1921, complication, empyema, left pleural cavity, hemolytic streptococcus type. Aspirated three times. March 20, 1920, thoracotomy; resection of 10 cm. of sixth rib anterior axillary line, left chest, with the institution of drainage, and cavity irrigated with Dakin's solution. June 9, 1921, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; poorly nourished; weight at present, 108 pounds. Examination of chest revealed sinus discharging pus sixth interspace, anterior axillary line, left

chest, and a cavity formation with a capacity of 200 c. c.; drainage not dependent. Radiographs showed a partial collapse of the left lung, with marked thickening of the parietal pleura from the first rib to the base, lateral chest, and a cavity formation extending from the second to the eighth rib posterior to the sinus leading into cavity. Clinical laboratory examination: Wassermann negative; sputum, negative for tubercle bacilli; white blood count, 16,650; red blood count, 4,610,000; urine, negative; culture from cavity showed hemolytic streptococci. Blood pressure: Systolic, 112; diastolic, 74; pulse pressure, 38. Vital capacity reading, 2,100 c. c.

July 8, 1921, operation; resection of 15 cm. of fifth, sixth, and seventh ribs, midaxillary line, left chest; excision of thickened parietal pleura forming roof of cavity; discission of visceral pleura to allow lung expansion; skin inverted over severed superficial muscles and fixed over ends of resected ribs to preserve it for final closure and to render dressing less painful; multiple scarifications of skin to lessen tension; cavity left wide open for active dakinization. August 10, 1921, discission of visceral pleura to allow lung expansion. Cavity now not one-fourth its original size, and cleaning up under dakinization. September 13, 1921, operation; plastic closure, with the implantation of a portion of the pectoralis major into the small remaining cavity

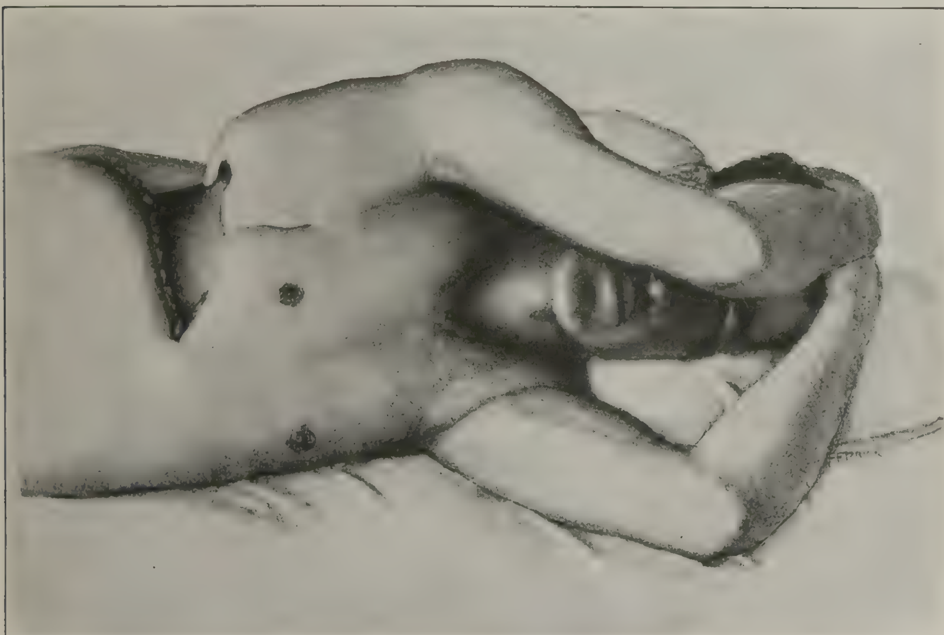

Fig. 117.—Case 23: The wound before closure.

which was not obliterated by lung expansion; the severed superficial muscles were brought into apposition and sutured with catgut; the skin freed and all scar tissue removed; edges brought in apposition and closed with figure-of-eight silkworm gut sutures; rubber dam drainage; multiple scarifications of the skin to lessen tension. November 5, 1921, patient healed and feeling splendidly; general condition excellent; weight at present, 127 pounds; vital capacity reading, 3,100 c. c.; discharged from hospital, cured, January 6, 1922.

Factors to be combated in this case were hemolytic streptococcus organism present; osteomyelitis of ribs; drainage not dependent.

Case 23.—C. J. W., age 27 years. January 5, 1918, developed pneumonia. January 12, 1918, complication, empyema, right pleural cavity, hemolytic streptococcus type. Aspirated eight times. January 22, 1918, thoracotomy; resection of 10 cm. of eighth rib, posterior axillary line, right chest; rubber tube valve inserted for drainage, and Carrel tubes used to instill Dakin's solution. Remained under treatment by this method until May 15, 1919, when he was discharged from the service with an open sinus still discharging pus. Returned to his home and remained there under treatment by a private physician, chest being reopened nine times to institute drainage of a large accumulation of pus. August 11, 1921, admitted to empyema service, Walter Reed General Hospital.

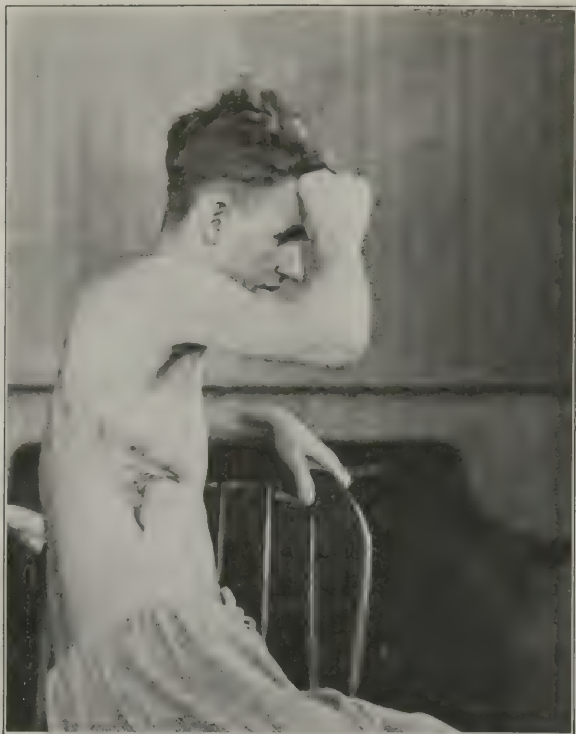

FIG. 118.—Case 23: A stage during healing of the wound.

FIG. 119.—Case 23: A lateral view of the final result.

Condition on admission: Ambulatory case; poorly nourished; present weight, 123 pounds (normal weight, 162 pounds). Examination of chest revealed sinus discharging pus, eighth interspace, posterior axillary line, right chest. Radiographs showed marked collapse of right lung with extensive thickening of pleura, lateral chest, from second rib to base; a cavity formation from fourth to tenth rib; a piece of rubber tubing, 2½ inches in length in the lower aspect of cavity. Pleurobronchial fistula present. Capacity of cavity, 400 c. c.; osteomyelitis with sequestration of the eighth and ninth ribs, which were fused and overlapping. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 9,200; red blood count, 4,500,000; urine showed trace of albumin; culture from cavity showed heavy growth of hemolytic streptococci. Blood pressure: Systolic, 142; diastolic, 84; pulse pressure, 58. Vital capacity reading, 1,800 c.c.

October 12, 1921, operation; resection of 15 cm. of the seventh, eighth and ninth ribs, posterior axillary line, right chest; cavity laid wide open and thickened parietal pleura excised; removal of Carrel valve or rubber tube which had been in cavity over two years; discission of visceral pleura to allow lung expansion; skin inverted over muscles to preserve it for final closure, and to render dressings less painful; preparation of cavity for Carrel-Dakin technique for its sterilization. October 31, 1921, operation; resection of anterior portion of seventh rib and part of costal cartilage, with a resection of 15 cm. of eighth rib, right chest, anterior axillary line, and the removal of overlying thickened pleura exposing secondary cavity; skin and muscle preserved for future closure; discission of visceral pleura to allow lung expansion. November 30, 1921, operation; resection of 20 cm. of fifth, sixth and seventh ribs, posterior scapular line, right chest, and resection of 5 cm. of eighth, ninth and tenth ribs same line, with removal of thickened pleura forming roof of secondary cavity which had been sterilized; discission of visceral pleura exposed, and implantation of a portion of the latissimus dorsi and subscapularis muscles into upper aspect of cavity; muscle and skin closure over this area. January 6, 1922, operation; resection of 10 cm. of the ninth, tenth and eleventh ribs, and excision of two sinus tracts, one following the course of the tenth rib and the other leading down to the twelfth rib, midaxillary line, right chest; skin inverted over muscle which was saved for future closure; area left open for active dakinization. February 6, 1922, operation; resection of 10 cm. of the fourth, fifth and sixth ribs, anterior axillary line, right chest, with the removal of the roof of another secondary cavity and the preparation of cavity for active dakinization. April 5, 1922, partial plastic closure of muscle and skin, with the implantation of portion of the superficial muscles into the upper aspect of the cavity, midaxillary line; injection of iodoform emulsion before area was closed; lower, anterior portion of secondary cavity likewise closed and skin and muscle brought in apposition and sutured with silkworm gut; emulsion injection; multiple scarification of skin to cause relaxation; rubber dam drainage for 48 hours. June 26, 1922, patient healed; fistula closed; all cavity formation obliterated; lung well expanded; general condition excellent; patient had taken on some weight; vital capacity reading, 2,500 c.c.


Fig. 120.—Case 23: Anterior view of the final result.

Factors to be combated in this case were hemolytic streptococcus organism present; Carrel valve rubber drainage tube left in cavity; osteomyelitis with rib sequestration; pleurobronchial fistula; secondary cavity and diverticula (five in number); nephritis, chronic, interstitial; tuberculosis, diagnosed by pathological specimen; chondritis of sixth, seventh and eighth costal cartilage.

Case 24.—J. R. S., age 27 years. October 25, 1918, received a perforating, high explosive gunshot wound, left chest, in action. Débridement operation 12 hours later, and chest closed following operation without drainage. Five days later he was aspirated, with the removal of 1,600 c.c. of purulent, bloody fluid; two additional aspirations followed with the removal of frank pus. November 16, 1918, thoracotomy; resection of a portion of the seventh and eighth ribs, left chest, and the institution of drainage. Allowed to close three months later, although patient was expectorating bloody pus. February 26, 1919, returned to the United States and hospitalized under the suspected diagnosis of tuberculosis, pulmonary, inactive, left lung. Patient at this time had a pneumothorax and a pleuropulmonary communication with a large cavity formation and abundant expectoration of bloody pus. Hemolytic streptococcus organism was present in expectoration. Treated for tuberculosis at two tuberculosis hospitals. Patient partially able to drain his cavity by lying on his right side and coughing. During his stay at these hospitals he received numerous aspirations with the removal of from 300 to 500 c.c. of pus. Sputum continued to be negative and patient was treated as a tubercuolsis suspect until his admission to Walter Reed Hospital. May 10, 1921, admitted to the empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; anemic; highly septic; poorly nourished; weight, 130 pounds (normal weight, 190 pounds); expectorating bloody pus. Examination of chest revealed marked lagging of the left side on deep inspiration; scar formation over the seventh and eighth ribs, posteriorly; impaired resonance to flat note over entire left chest, breath sounds distant. Radiographs showed marked collapse of left lung, extensive thickening of parietal pleura from apex to base and a large cavity formation extending from fifth to ninth ribs; posterior chest partially filled with fluid. A small metallic foreign body was noted in the region of the left hilus. Pleurobronchial fistula present. Patient able to partially drain his cavity. There was osteomyelitis of the previously resected rib stumps. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 10,700; red blood count, 4,190,000; urine negative; culture from expectorated pus revealed hemolytic streptococcus and this organism was also present in cultures from cavity, when the latter was opened. Blood pressure: Systolic, 115; diastolic, 70; pulse pressure, 45. Vital capacity not taken.

May 20, 1921, operation; resection of 15 cm. of seventh, eighth, and ninth ribs, posterior scapular line, left chest; roof of cavity over this area excised; cavity laid wide open; pleurobronchial fistula exposed; 100 c.c. pus evacuated; preparation of cavity for active dakinization. June 4, 1921, operation; extension of incision along posterior border of scapula; resection of 15 cm. of sixth and seventh ribs; excision of thickened parietal pleura; cavity laid wide open; closure of bronchial fistula by purse-string suture, the communication being one of the main limbs of the bronchial tree near hilus; lung mobilized in this area and the implantation of muscle flap, part of the infraspinatus, over the site of the fistula; cavity prepared for active dakinization; skin inverted over severed muscles and fixed; wound firmly packed. Two hours later patient had secondary hemorrhage from the vessels of the hilus; active measures to control bleeding were instituted but there was considerable bleeding before hemorrhage could be controlled. Patient passed into profound shock and in spite of all combative measures died one hour later.

Factors to be combated were hemolytic streptococcus present; pleurobronchial fistula of one of the main bronchi near the hilus; osteomyelitis of resected rib stumps; no drainage except through expectoration; long-continued sepsis.

Case 25.—C. O. R., age 19 years. February 13, 1921, developed measles; followed by pneumonia, April 1, 1921; and complicated by empyema, left pleural cavity, hemolytic streptococcus type, May 24, 1921. Aspirated six times. May 29, 1921, thoracotomy; resection of 10 cm. of eighth rib, posterior axillary line, with the institution of drainage. Irrigated daily. October 18, 1921, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; fairly well nourished; normal weight, 158 pounds; present weight, 145 pounds. Examination of chest revealed sinus discharging pus, eighth inter-

space, posterior axillary line, left chest, and a cavity formation with a capacity of 100 c. c. Radiographs showed a partial collapse of the left lung with some thickening of the pleura from the fourth to ninth rib, left lateral chest, and a cavity formation, extending from the seventh to the ninth rib, filled with pus and containing a rubber tube in its lower aspect; heart displaced to the right. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 17,460; red blood count, 4,700,000; urine negative; culture from cavity showed hemolytic streptococcus and staphylococcus aureus. Blood pressure: Systolic, 138; diastolic, 88; pulse pressure, 50. Vital capacity reading, 2,700 c. c.

November 2, 1921, resection of 15 cm. of eighth and ninth ribs, posterior axillary line, left chest; excision of thickened parietal pleura forming roof of cavity; the removal of a 3-inch rubber tube and the evacuation of 100 c. c. of pus; skin fixed over severed muscle to prevent retraction; and cavity left wide open for active dakinization. December 1, 1921, cavity sterile after seven consecutive daily cultures; the lung had reexpanded and completely obliterated all cavity; only a small granulating wound of the skin and superficial tissues remained unhealed. December 15, 1921, patient healed and feeling well; lung well expanded; general condition excellent; weight at present, 164 pounds; vital capacity reading, 3,800 c. c. Discharged from hospital, cured, January 6, 1922.

Factors to be combated in this case were hemolytic streptococcus present; foreign body (rubber tube) which had remained in cavity for three months; osteomyelitis of eighth and ninth ribs.


Fig. 121.—Case 26: Area beneath angle of scapula to be closed by skin and muscle suture.

Case 26.—J. W. W., age 27 years. May 16, 1918, developed influenza, complicated by empyema, left pleural cavity, hemolytic streptococcus type, June 8, 1918. Aspirated once. June 10, 1918, operation: thoracotomy; resection of 10 cm. of seventh rib, anterior axillary line, left chest; pleural cavity opened and 500 c. c. of pus evacuated; rubber-tube valves inserted into cavity for drainage. October 5, 1918, operation: thoractomy; resection of a portion of the proximal end of the left seventh rib, and the institution of drainage. January 12, 1919, incision, with institution of drainage. September 17, 1919, resection of a portion of the seventh rib and regenerated bone, and drainage again instituted with a Dakin solution irrigation. Discharged from service February, 1920, and taken over as a Public Health patient, being treated in a number of hospitals, and was sent to Mont Alto, Pa., for treatment of suspected tuberculosis. December 5, 1921, admitted to empyema service, Walter Reed General Hospital.

Condition of admission: Ambulatory case; poorly nourished; normal weight, 165 pounds; present weight, 148 pounds; joints of extremities edematous and tender; persistent cough, with the expectoration of frank pus; highly septic; fingers clubbed. Examination of chest revealed marked lagging of the left side on deep inspiration; scar formation over the seventh rib from the anterior to the posterior axillary line; percussion revealed impaired resonance to flat note from second rib to base of left chest; auscultation breath sounds distant and indistinct. Radiographs showed marked collapse of left lung, with extensive thickening of pleura, left lateral chest, from second rib to base,

and a large cavity formation filled with fluid and extending from fourth rib, posterior chest, down to ninth rib; marked displacement of heart to the right. Pleurobronchial fistula present and patient was partially able to drain his cavity by lowering his head and coughing. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 12,700, red blood count, 4,200,000; urine negative; culture from cavity showed heavy growth of hemolytic streptococcus. Blood pressure: Systolic, 122; diastolic, 80; pulse pressure, 32. Vital capacity reading, 2,000 c. c.

December 14, 1921, operation; resection of 20 cm. of sixth, seventh, eighth, and ninth ribs, posterior axillary line, left chest; cavity laid wide open and 500 c. c. of pus evacuated; the thickened parietal pleura, forming roof of cavity, excised; discission of the visceral pleura to allow lung expansion and to mobilize the lung about fistula; skin inverted over muscle to preserve it for final closure; and cavity prepared for the Carrel-Dakin technique. January 5, 1922, discission of visceral pleura and the treatment of fistula with a 2 per cent alcoholic solution of gentian violet to mechanically plug it until granulations entirely obliterate communication. February 20, 1922, cavity entirely obliterated; pleurobronchial fistula closed; and wound sterile by seven consecutive daily cultures. February 24, 1922, operation; partial secondary closure; upper and posterior aspect of wound closed by muscle and skin with silkworm gut; and rubber dam drainage. March 8, 1922, operation; secondary closure, lower aspect of wound; all scar tissue removed and muscle and skin brought in apposition and sutured; rubber dam drainage; and multiple scarification of skin to cause relaxation and relieve tension. March 20, 1922, patient entirely healed; general condition excellent; weight on admission, 148 pounds; weight at present, 170 pounds; vital capacity reading, 3,200 c. c. June 15, 1922, patient discharged, entirely cured; healed two months; condition excellent.

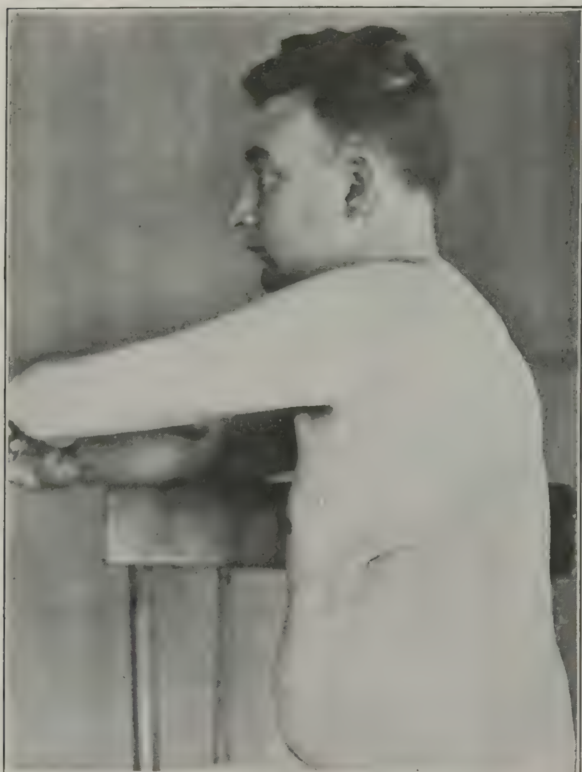

FIG. 122.—Case 26: Lateral view of final result.

Factors to be combated in this case were hemolytic streptococcus present; pleurobronchial fistula present; osteomyelitis with sequestration of rib.

CASE 27.—C. F. N., age 20 years. February 4, 1921, developed pneumonia; complicated by empyema left pleura cavity, hemolytic streptococcus type, May 3, 1921. Aspirated once. May 5, 1921, thoracotomy; resection of 10 cm. of eighth rib, posterior scapular line, with the evacuation of 500 c. c. of pus and the institution of drainage; Dakin's solution used to irrigate cavity. December 3, 1921, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; well nourished; about normal in weight (145 pounds). Examination of chest: Sinus discharging pus, eighth interspace posterior scapular line, left chest. Radiographs showed partial collapse of left lung, with some thickening of parietal pleura, left lateral chest, and a cavity formation extending from sixth to tenth rib, posterior scapular line, with a capacity of 100 c. c.; osteomyelitis of eighth and ninth ribs in the area of primary operation. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 9,800; red blood count, 4,890,000; urine negative; culture from cavity showed hemolytic streptococcus and staphylococcus aureus. Blood pressure: Systolic, 126; diastolic, 82; pulse pressure, 44. Vital capacity reading, 2,800 c. c.

December 8, 1921, operation; resection of 15 cm. of the seventh, eighth, and ninth ribs, posterior scapular line; excision of thickened parietal pleura forming roof of cavity; discission of visceral pleura to allow lung expansion; skin inverted over muscle to preserve it for final closure; and preparation of cavity for the Carrel-Dakin technique. January 20, 1922, lung had expanded and cavity was down to one-fourth its size and was sterile: patient's general condition was excellent. January 24, 1922, plastic closure; a portion of the latissimus dorsi implanted into the remaining space and the severed superficial muscles and skin brought in apposition and sutured; rubber dam drainage along suture line. February 15, 1922, patient completely healed and feeling well. Appetite improved; gain weight and strength. March 1, 1922, patient healed; general condition excellent; weight, 150 pounds. Vital capacity reading, 3,900 c. c. May 16, 1922, patient discharged, cured. Healed three months.

Factors to be combated in this case were hemolytic streptococcus present; primary drainage not dependent; osteomyelitis of eighth and ninth ribs.

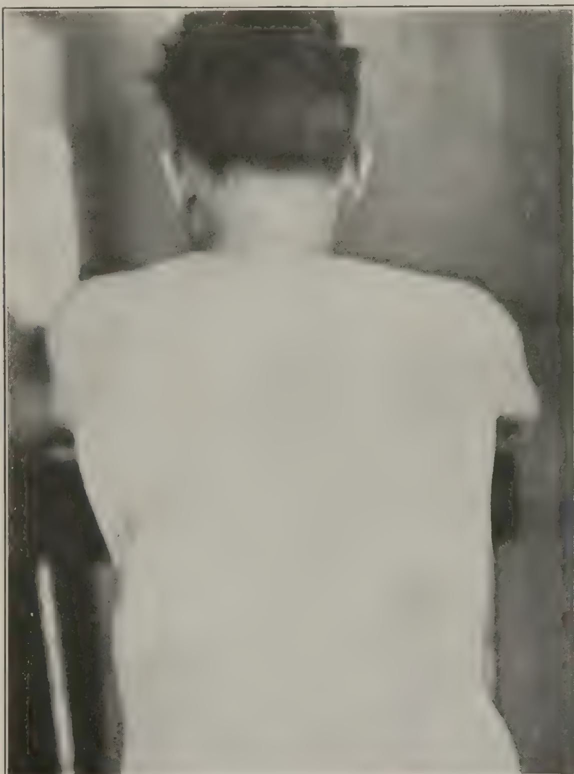

FIG. 123.—Case 26: Posterior view of final result.

CASE 28.—B. F. L., age 28 years October 13, 1918, was gassed in action in Argonne Forest (patient's statement), and was treated in hospital until December, 1918. Discharged from service February 27, 1919. Developed influenza and pneumonia March 1, 1919; complicated by empyema, left pleural cavity, hemolytic streptococcus type, March 20, 1919. Aspirated twice. March 28, 1919, operation; thoracotomy; resection of a portion of the eighth rib posterior axillary line, with the institution of drainage. June 8, 1920, thoracotomy; resection of a portion of the seventh rib, posterior axillary line, and the removal of regenerated eighth rib in the area of operation, with the institution of drainage. October 29, 1920, operation; resection of an additional portion of the anterior stumps of the seventh and eighth ribs, with the institution of drainage. Patient stated that he was reopened to institute drainage eleven times in addition to the above operations. January 20, 1922, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; poorly nourished; normal weight, 140 pounds; present weight, 117 pounds; extremities edematous; patient showed the facies of sepsis; fingers clubbed; and marked anemia present. Examination of chest revealed sinus discharging pus seventh interspace, posterior axillary line, left chest; pleurobronchial fistula present. Radiographs showed marked collapse of left lung; extensive thickening of the parietal pleura from apex to base, left lateral chest, and a large cavity (capacity of 450 c. c.) partially filled with pus, extending from this rib to ninth rib, the upper aspect of cavity communicating with the main cavity only by means of a small sinus. Clinical laboratory examination: Wassermann plus minus (had been double plus and patient had received two courses of antisyphilitic treatment); sputum negative for tubercle bacilli; white blood count, 18,550; red blood count, 4,130,000; urine showed trace of albumin; culture from cavity showed hemolytic streptococci. Blood pressure: Systolic, 110; diastolic, 74; pulse pressure, 36. Vital capacity reading, 1,700 c. c.

January 23, 1922, operation; resection of 20 cm. of sixth, seventh, eighth, and ninth ribs, posterior axillary line, left chest; removal of thickened parietal pleura and the excision of thick bands of fibrous tissue dividing the main cavity into three subcavities; the fistula exposed and the skin inverted over the severed muscles; cavity left open for active dakinization. February 23, 1922, operation; resection of 20 cm. of fourth and fifth ribs and 5 cm. of the posterior stumps of the sixth and seventh ribs; excision of parietal pleura forming roof of secondary cavity; discission of visceral pleura to allow lung expansion; cavity left wide open for active dakinization; skin inverted over severed muscles and fixed over rib ends to prevent retraction and to render dressing less painful; multiple scarifications of skin to relieve tension. March 8, 1922, fistula closed by means of repeated applications of a 2 per cent alcoholic solution of gentian violet; cavity appeared to be cleaning up; patient's general condition greatly improved; all edema had disappeared from extremities. March 23, 1922, resection of 10 cm. of third and fourth ribs, posterior scapular line; removal of roof of secondary cavity and remaining sinus injected with iodoform emulsion; muscle implantation into apex of cavity to obliterate the remaining space; and continuation of active dakinization of entire cavity. June 9, 1922, resection of a portion of second, third, fourth, fifth and sixth ribs, posterior scapular line, left chest; excision of thickened parietal pleura forming roof of cavity; entire secondary cavity exposed and complete area left open for active dakinization. June 26, 1922, patient on active dakinization; entire cavity wide open. Bacterial count showed several sterile cultures. All edema of feet and ankles had cleared up. General condition greatly improved.

Because this patient was undergoing vigorous antisyphilitic treatment the cavity was left open.

Factors to be combated in this case were hemolytic streptococcus present; thickened pleura; faulty drainage; scoliosis; accessory cavity.

Case 29.—C. A. W., age 30 years. December 4, 1918, developed influenza and pneumonia; complicated by empyema, left pleural cavity, hemolytic streptococcus type, December 26, 1918. Aspirated once. December 27, 1918, thoracotomy; resection of a portion of the ninth rib, posterior axillary line, with the institution of better drainage, irrigated with Dakin's solution once daily to cleanse cavity. Discharged from the Service September 5, 1920, still draining. Patient stated that he had closed and had been reopened eight times to institute drainage. January 15, 1922, admitted to the empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; poorly nourished and considerably under weight; anemic and with a septic appearance; extremities edematous; fingers clubbed, weight on admission 135 pounds. Examination of chest revealed sinuses discharging pus over seventh and ninth ribs, posterior axillary line, left chest; pleurobronchial fistula present. Radiographs showed marked collapse of left lung with some fibrosis; extensive thickening of the parietal pleura from the second rib to the base, left lateral chest, and a cavity formation filled with pus extending from third rib to ninth rib. Capacity of cavity about 400 c. c. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 16,450; red blood count, 4,580,000; urine negative; culture from cavity showed hemolytic streptococcus and staphylococcus aureus. Blood pressure: Systolic, 128; diastolic, 80; pulse pressure, 48. Vital capacity reading, 1,600 c. c.

January 23, 1922, operation; resection of 30 cm. of seventh, eighth, ninth and tenth ribs posterior axillary line, left chest, excision of roof of cavity and thickened parietal pleura and the exposure of part of the cavity and the pleuropulmonary communication; skin inverted over muscle and saved for final closure; cavity left wide open for active dakinization. February 13, 1922, operation; resection of 20 cm. of fourth, fifth and sixth ribs, posterior scapular line, left chest; removal of thickened parietal pleura overlying cavity and secondary cavity exposed; discission of visceral pleura to allow lung expansion; entire cavity left wide open for active dakinization. March 8, 1922, patient's general condition greatly improved; cavity one-half its original size and apparently cleaning up; no edema of extremities present. May 29, 1922, plastic closure, muscle and skin, with the implantation of a portion of the subscapularis and latissimus dorsi muscles; tissues brought in apposition by means of silkworm gut sutures; rubber dam and two Carrel tubes used for drainage for 48 hours; multiple scarification of skin to cause relaxation. June 26, 1922, there were three small sinuses along suture line as result of infection following plastic closure, which were being gradually obliterated; lung well expanded; general condition excellent; patient was taking on some weight; vital capacity reading, 2,600 c. c. Patient entirely healed.

Factors to be combated in this case were hemolytic streptococcus present; pleurobronchial fistula present; fibrosis of lung; secondary cavities or diverticula; diminished vital capacity.

Case 30.—A. T., age 30 years. November 27, 1921, received gunshot wound, perforating, left chest; complicated by empyema, left pleural cavity, hemolytic streptococcus type, December 5. 1921. Aspirated four times. Received two operations prior to admission to this hospital with resection of seventh and eighth ribs, midscapular line, left chest with the institution of drainage, February 14, 1922, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; poorly nourished; under weight: highly septic and showing some anemia; weight on admission, 120 pounds (normal weight, 154 pounds). Examination of chest: Sinus discharging pus eighth interspace, midscapular line, left chest; pleurobronchial fistula present. Radiograph showed some collapse of left lung with considerable thickening of parietal pleura, left lateral chest, and a cavity formation extending transversely in region of fifth, sixth, and seventh ribs, which was partially filled with pus and having a capacity of about 300 c. c. Clinical laboratory examination: Wassermann negative; urine showed trace of albumin; sputum negative for tubercle bacilli; red blood count, 3,960,000; white blood count, 10,800; hemoglobin, 75 per cent; pus from cavity showed hemolytic streptococci. Blood pressure: Systolic, 118; diastolic, 80; pulse pressure, 38. Vital capacity reading, 1,900 c. c.

March 13, 1922, resection of 15 cm. of fifth, sixth, seventh, and eighth ribs, posterior axillary line; excision of thickened parietal pleura over cavity; discission of visceral pleura and lung freed about fistula; cavity left open for active dakinization; skin inverted over superficial muscle to preserve it for final closure. May 4, 1922, excision of diverticulum and entire cavity left open for continued dakinization; small detached sequestra removed from angle of scapula; and superficial muscle brought over angle of scapula and fixed. May 18, 1922, plastic closure of remaining empyema cavity with the implantation of both muscle and skin flap in situ; the entire area closed; muscle and skin brought in apposition and sutured by means of silkworm gut; multiple scarifications of skin to cause relaxation and to prevent slough; rubber dam drainage for 24 hours. June 5, 1922, there were two small areas along the suture line which were not healed as the result of infection following plastic closure. These were being gradually obliterated. June 26, 1922, all but healed; two small areas described above were nearly obliterated and had no connection with the empyema cavity; lung was well expanded; cavity formation had been obliterated; general condition excellent; patient had taken on weight. Weight on admission, 120 pounds; present weight, 147 pounds. Vital capacity reading, 3,100 c.c.

Factors to be combated were hemolytic streptococcus present; osteomyelitis with sequestration of ribs and angle of scapula; pleurobronchial fistula; diverticulum and secondary cavity; bullet tract through lung to be obliterated.

Case 31.—W. R., age 28 years. February 1, 1917, developed pneumonia; complicated by empyema, right pleural cavity, hemolytic streptococcus type, February 11, 1917. Aspirated three times. February 14, 1917; operation; thoracotomy; resection of a portion of the ninth rib, posterior axillary line; and the institution of drainage. Patient healed March 6, 1918, and entered the military service May 28, 1918. Remained on active duty without recurrence until June 28, 1919, when he was discharged from the service. July 6, 1919, developed a recurrence of empyema. July 8, 1919, operation; incision and drainage, and irrigation with Dakin's solution daily. Had healed and been reopened at least 15 times. March 29, 1922, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; well nourished; normal in weight; but slightly anemic and highly septic. Weight on admission, 180 pounds. Examination of chest revealed sinus discharging pus ninth interspace, midscapular line, right chest. Radiograph showed some collapse of the right lung and extensive thickening of the parietal pleura from apex to base, right lateral chest; cavity formation extending transversely from seventh to ninth rib, with a capacity of 250 c.c. Clinical laboratory examination: Wassermann double plus; sputum negative for tubercle bacilli; red blood count, 4,110,000; white blood count, 10,700; hemoglobin, 80 per cent; urine negative; culture from cavity showed hemolytic streptococci. Blood pressure: Systolic, 130; diastolic, 80; pulse pressure, 50. Vital capacity reading, 2,900 c.c.

March 31, 1922, resection of 20 cm. seventh, eighth, and ninth ribs, posterior axillary line, excision of thickened parietal pleura; entire cavity laid wide open; two diverticula draining into main cavity were excised; implantation of a portion of the serratus magnus into the anterior aspect of the cavity; skin inverted over superficial muscles and fixed; multiple scarification of skin to cause relaxation; preparation of cavity for active dakinization. April 17, 1922, resection of 10 cm. of the ninth and tenth ribs midaxillary line to remove osteomyelitic involvement; skin

inverted over superficial muscle; entire cavity left wide open for continued dakinization. May 31, 1922, excision of sinus tract draining into main cavity; removal of a sequestrum or detached particles of rib fragments in area of seventh rib; entire area left open for continued dakinization. June 21, 1922, plastic closure, muscle and skin; implantation of portion of superficial muscle body into remaining space; after maximum lung expansion had been obtained; all scar tissue excised; severed muscles and skin brought in apposition by means of silkworm gut sutures; rubber dam drainage for 48 hours; multiple scarification of skin to cause relaxation. June 28, 1922, all sutures removed and area healed by primary intention; lung was well expanded; general condition excellent; vital capacity, 3,400 c.c.

Factors to be combated were hemolytic streptococcus present; osteomyelitis with sequestration; diverticula and numerous sinus tracts draining into remaining cavity; syphilis, tertiary, manifested by double plus Wassermann; profuse acne.

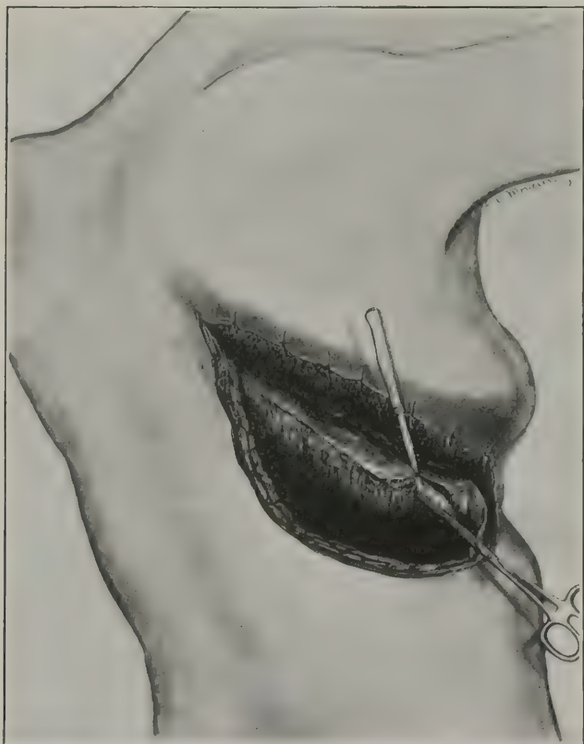

FIG. 124.—Case 33: A stage in the plastic closure by muscle implantation.

CASE 32.—J. M. P., age 28 years. October 12, 1921, developed pneumonia; complicated by empyema, right pleural cavity, hemolytic streptococcus type, November 12, 1921. Aspirated once. Received two operations prior to admission to Walter Reed General Hospital, with resection of the seventh and ninth ribs and the institution of drainage, and the instillation of Dakin's solution once daily to cleanse cavities. February 14, 1922, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; fairly well nourished but highly septic and showing some anemia; normal weight, 150 pounds; present weight, 133 pounds. Examination of chest revealed two sinuses discharging pus, one in the seventh interspace and the second in the ninth interspace, posterior axillary line, left chest. Radiographs showed some collapse of the right lung and considerable thickening of parietal pleura from the third rib to base, and a cavity formation, hour glass in character, extending from the sixth to tenth rib, with a capacity of 350 c.c. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; red blood count, 4,180,000; white blood count, 18,950; hemoglobin, 70 per cent; urine showed trace of albumin, many pus cells; culture from cavity showed hemolytic streptococcus. Blood pressure: Systolic, 136; diastolic, 88; pulse pressure, 48. Vital capacity reading, 2,200 c.c.

This case was treated by the sterilization method due to its short duration; but under the most rigid Carrel-Dakin technique the cavity infection failed to clear up, hence this method of treatment was abandoned and surgical intervention instituted.

April 10, 1922, resection of 15 cm. of the seventh and eighth ribs, posterior scapular line, and resection of 10 cm. of the ninth and tenth ribs, midaxillary line; excision of thickened parietal pleura forming roof of cavity; entire area laid wide open for active dakinization; skin inverted over severed superficial muscles and fixed to preserve them for final closure; multiple scarification to cause relaxation along suture line. May 25, 1922, resection of necrotic rib stumps of seventh

and eighth ribs, previously resected; excision of small sinus tract draining into main cavity; entire area left open for continued dakinization. June 20, 1922, plastic closure by muscle and skin, with implantation of superficial muscle body into remaining space after maximum lung expansion had been obtained; all scar tissue excised; muscle and skin brought in apposition by means of silkworm gut sutures. Rubber dam drainage for 48 hours; multiple scarification of skin to cause relaxation and prevent future slough. June 28, 1922, all sutures removed and area found healed by primary intention. Lung was well expanded; general condition was excellent; weight, 111 pounds; vital capacity reading, 3,400 c.c.

Factors to be combated were hemolytic streptococcus; osteomyelitis with rib sequestration; diverticulum or secondary cavity.

Case 33.—J. W. S., age 26 years. February 19, 1919, developed pneumonia; complicated by empyema, right pleural cavity, hemolytic streptococcus type, April 1, 1919. Aspirated three times. April 9, 1919, operation; thoracotomy; resection of 5 cm. of eighth rib, posterior axillary line; and the institution of drainage. October 19, 1919, operation; resection of 15 cm. of seventh, eighth, and ninth ribs, posterior axillary line, with removal of parietal pleura and decortication of visceral pleura; lower aspect of wound left open for drainage. November 27, 1920, admitted to empyema service, Walter Reed General Hospital.

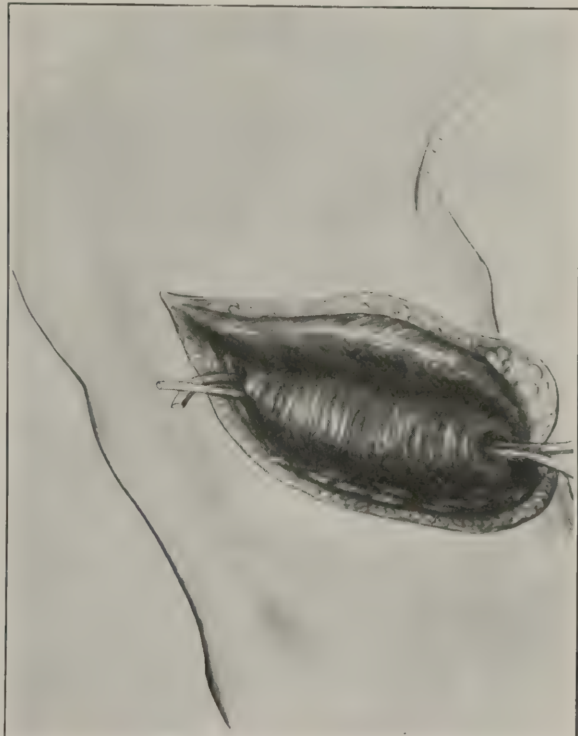

Fig. 125.—Case 33: Second stage in the muscle implantation.

Condition on admission: Ambulatory case; fairly well nourished and about normal in weight (175 pounds). Examination of chest revealed sinus discharging pus ninth interspace, posterior axillary line, right chest. Radiographs showed ribs resected as enumerated above and a marked thickening of the parietal pleura, right lateral chest, with a partial collapse of right lung and a cavity formation with a capacity of about 200 c. c. Clinical laboratory examination: Wassermann negative; sputum positive for tubercle bacilli; white blood count, 8,600; red blood count, 4,620,000; urine negative; culture from cavity showed hemolytic streptococcus and bacillus proteus. Blood pressure: Systolic, 118; diastolic, 82; pulse pressure, 36. Vital capacity reading, 2,600 c. c. January 13, 1922, operation; resection of 20 cm. of seventh, eighth, and ninth, and tenth ribs, posterior scapular line, cavity being laid widely open; discission of visceral pleura; active dakinization followed and the cavity was obliterated by re-expansion of the lung until it was about one-fifth its original size. Seven consecutive daily cultures showing no growth were obtained and maximum amount of lung expansion occurred. April 6, 1921, operation; plastic closure of defect by muscle implantation; severed superficial muscles brought in apposition and sutured; skin closed with silkworm gut and rubber dam drainage instituted between the sutures along the suture line. May 15, 1921, patient entirely healed; general condition good; weight, 180 pounds; vital capacity reading, 3,100 c. c. June 14, 1921, transferred to General Hospital No. 19, Oteen, N. C., for active pulmonary tuberculosis. Empyema healed.

Factors to be combated in this case were hemolytic streptococcus organism present; primary drainage was not dependent; active pulmonary tuberculosis; osteomyelitis of resected rib stumps.

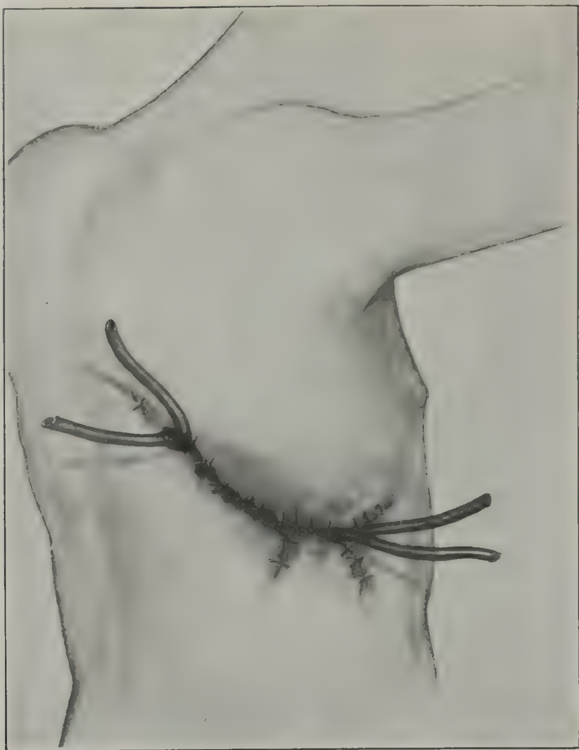

FIG. 126.—Case 33: Final skin suture.

FIG. 127.—Case 33: Final result.

CASE 34.—P. F. H., age 30 years. September 10, 1918, developed influenza, American Expeditionary Forces, France. Discharged from service July 8, 1919. Second attack of influenza August 2, 1920; complicated by empyema, right pleural cavity, hemolytic streptococcus type, September 1, 1920. Aspirated five times. September 9, 1920, operation; thoracotomy; resection of 10 cm. of sixth rib, midaxillary line, with the institution of drainage. October 3, 1921, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; poorly nourished; weight, 125 pounds (normal weight, 145 pounds), fingers clubbed; anemic. Examination of chest revealed sinus discharging pus sixth interspace midaxillary line with a large cavity formation filled with pus. Radiographs showed marked collapse of right lung with extensive thickening of parietal pleura, right lateral chest, from apex to base, and a cavity formation, with a capacity of 500 c. c., extending from second rib to eighth rib; osteomyelitis with sequestration of sixth and seventh ribs, midaxillary line. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 16,150; red blood count, 4,120,000; urine negative; culture from cavity showed hemolytic streptococci. Blood pressure: Systolic, 108; diastolic, 78; pulse pressure, 30. Vital capacity reading, 1,700 c. c.


FIG. 128.—Case 35: The first fractional operation in the treatment of a chronic empyema cavity.

October 12, 1921, resection of 15 cm. of sixth, seventh, and eighth ribs, posterior axillary line, right chest, excision of thickened parietal pleura forming roof of cavity; evacuation of about 500 c. c. of pus; skin inverted over muscles that were severed; and cavity left open for active dakinization. October 16, 1921, patient on active dakinization and improving. With the thickening of the parietal pleura and the fixation of the lung in such a firm state of collapse, this case evidently had some pleural involvement with his first attack of influenza. This was not noticed or at least did not receive surgical attention. November 29, 1921, operation; resection of 20 cm. of fourth, fifth, sixth, seventh, and eighth ribs, anterior axillary line; excision of roof of cavity and preparation of cavity for active dakinization. December 30, 1921, operation; resection of 10 cm. of fourth, fifth, sixth, seventh ribs, posterior scapular line, right chest; excision of thickened parietal pleura; discission of visceral pleura; skin brought over muscle and fixed to prevent retraction and to preserve it for future closure; multiple scarifications of skin to cause relaxation; cavity left open for dakinization. February 3, 1922, operation; resection of 5 cm. of fourth and fifth ribs which showed some necrosis; cavity left wide open for active dakinization. March 8, 1922, patient improving; lung expanding and cavity cleaning up. March 13, 1922, resection of necrosed rib previously resected; removal of a portion of the fifth rib, anterior aspect; excision of sinus tract; preparation of entire cavity for active dakinization. May 17, 1922, plastic closure by muscle and skin, anterior aspect of cavity; posterior aspect left open for continuation of dakinization; multiple scarifications of skin to cause relaxation; rubber dam and Carrel tube drainage for 48 hours.

Factors to be combated in this case were osteomyelitis of rib stumps; hemolytic streptococcus present.

CASE 35.—H. J., age 28 years. December 8, 1919 developed influenza, complicated by empyema December 10, 1919. Aspirated once. January 6, 1920, patient was operated on at his

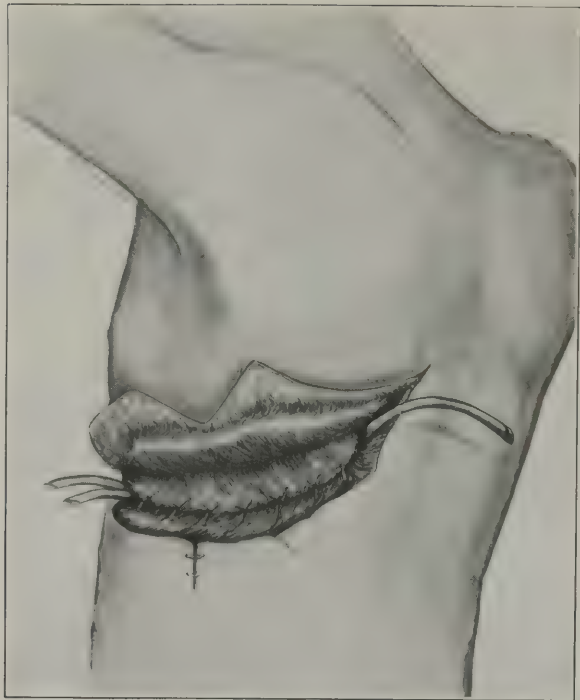

FIG. 129.—Case 35: Plastic implantation of muscle.

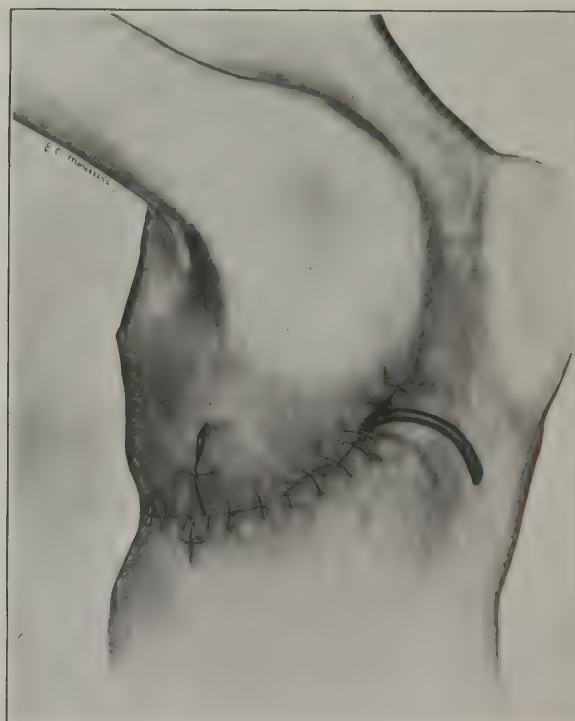

FIG. 130.—Case 35: The final suture and closure of the cavity.

home and a small section of the tenth rib resected. Drainage was instituted. Patient continued to drain. May 29, 1920, operation by civilian physician; resection of portion of ninth rib; drainage continued until date of admission. December 1, 1920, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: General condition fairly good; weight, 145 pounds (normal weight, 160 pounds); fairly well nourished. Examination of chest showed two sinuses at the level of the ninth and tenth ribs, respectively, with exuberant granulations, and discharging heavy, thick pus; a probe could be inserted for a distance of about 20 cm. Radiograph showed a cavity extending from the point of resection of the ninth and tenth ribs from the midscapular line to the anterior axillary line at the level of the midportion of the lung. There was some collapse of the lung with a thickening of the pleura along the lower lateral chest wall. Clinical laboratory examination: Wassermann negative; urine negative; sputum negative for tubercle bacilli; red blood count, 4,300,000; white blood count, 7,100; hemoglobin, 80 per cent; culture from cavity showed streptococcus hemolyticus and staphylococcus aureus.

Fig. 131.—Case 35: The final result obtained by fractional procedures.

Drainage and active dakinization of the cavity was immediately started with a view to getting it as clean as possible before operation.

January 12, 1921, resection of the eighth, ninth, and tenth ribs overlying the sinus tract. On the removal of the intercostal structures and the parietal pleura, a cavity, 8 inches long and 1 inch wide was exposed with an accessory cavity draining through a small sinus into the first cavity and lying at right angles to it at its midportion. The secondary cavity was about 4 inches long and 2 inches wide. The cavity was completely exposed and after the severed muscle bodies on either side of the wound were tucked in and covered over by sliding the undermined skin forward and suturing it into place, the wound was packed with gauze in preparation for the usual Dakin treatment. After operation patient put on weight rapidly, the wound was obliterated in a short time and the lung expanded until only a superficial gutter was left with the visceral pleura forming the floor. March 31, 1921, plastic operation under local anesthesia; excision of all scar tissue; the skin and subcutaneous tissues covering the previously prepared muscle bodies undermined and dissected up; the muscle body was split and its lower half was implanted into the upper angle of the wound and sutured to the visceral pleura filling up the gap; the lower half of the wound was covered over by sliding forward the skin flaps from either side. Two Carrel tubes were inserted beneath the muscle implanted for the instillation of Dakin's solution for a few days and rather firm dressing was applied. All drainage was discontinued after a week and the wound healed by first intention. Just previous to the above plastic operation a small sinus was found leading forward from the anterior angle of the wound. The sinus was split open and one of the resected rib stumps found necrotic. May 18, 1921, patient discharged.

Factors to be combated were hemolytic streptococcus present; thickened pleura; faulty drainage; diverticulum or secondary cavity; scoliosis.

CASE 36.—G. M. A., aged 23 years. March 23, 1921, developed pneumonia; complicated by empyema, left pleural cavity, hemolytic streptococcus type, May 1, 1921. Aspirated three times. May 9, 1921, operation: thoracotomy: resection of 10 cm. sixth, rib, anterior axillary line, with the institution of drainage, and irrigation with Dakin's solution daily. June 9, 1921, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; poorly nourished; anemic; showing some loss in weight; marked shortness of breath. Present weight, 111 pounds. Examination of chest revealed sinus discharging pus sixth interspace, anterior axillary line, left chest: pleurobronchial fistula present; and a cavity formation with a capacity of 200 c. c. Radiographs showed partial collapse of left lung with some thickening of the parietal pluera, left lateral chest, from the second to ninth rib, and a cavity formation running transeversely across the chest from the nipple line anterior to the posterior scapular line, the lower aspect of it being on a level with the seventh rib: heart slightly displaced to the right and posteriorly. Clinical laboratory examination: Wassermann negative. sputum negative for tubercle bacilli; white blood count, 19,300; red blood count, 4,720,000; urine negative; culture from cavity showed hemolytic streptococcus and staphylococcus aureus. Blood pressure: Systolic, 115; diastolic, 82; pulse pressure, 33. Vital capacity reading not taken.

June 30, 1921, operation; resection of 20 cm. of seventh rib, posterior axillary line, left chest; cavity laid wide open and lung freed about fistula and allowed to retract, thus mobilizing site of fistula; skin fixed over muscles which were severed to prevent retraction; cavity left wide open for active dakinization. July 25, 1921, lung well expanded; fistula closed and wound well granulated: cavity obliterated; seven consecutive sterile cultures having been obtained, cavity was allowed to close. September 15, 1921, patient entirely healed and feeling well; general condition excellent: weight, 135 pounds. Vital capacity reading, 3,200 c. c. Discharged from the service and hospital as cured December 8, 1921.

Factors to be combated in this case were hemolytic streptococcus present; pleurobronchial fistula present; drainage not dependent.

CASE 37.—O. C., age 22 years. December 20, 1919, developed influenza; complicated by empyema, right pleural cavity, hemolytic streptococcus type, January 25, 1920. Aspirated twice. February 3, 1920, thoracotomy; resection of 5 cm. of the sixth rib anterior axillary line, right chest. March 12, 1920, operation: incision and drainage. May 15, 1920, chest allowed to close. June 28, 1920, operation; incision and the institution of drainage. Chest was allowed to close and was reopened six times. October 2, 1920, admitted to the empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory; patient anemic; weight, 149 pounds (normal weight, 160 pounds). Examination of chest revealed sinus discharging pus, anterior axillary line, sixth interspace, right chest. Radiographs showed partial collapse of right lung, with marked thickening of the parietal pleura, and a cavity triangular in outline and about 6 to 8 cm. deep, extending upward; heart, aorta and trachea displaced to the right. Capacity of cavity, 150 c. c. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 8,500; red blood count, 4,380,000; urine negative; culture from cavity showed heavy growth of hemolytic streptococci. Blood pressure: Systolic, 115; diastolic, 76; pulse pressure, 39. Vital capacity reading, 2,800 c. c.

October 21, 1920, resection of 20 cm. of sixth, seventh, and eighth ribs; posterior axillary line cavity laid wide open and prepared for active dakinization. December 1, 1920, secondary closure with plastic muscle flap using a portion of the latissimus dorsi muscle; superficial, severed muscles brought in apposition and skin sutured. March 20, 1921, patient entirely healed; general condition excellent; weight on admission, 149 pounds; weight on discharge, 160 pounds. Vital capacity reading, 3,400 c. c. Patient completely cured and discharged May 26, 1921.

Factors to be combated in this case were hemolytic streptococcus present, primary drainage was not dependent; cavity led directly into mediastinum.

CASE 38.—A. M., age 27, October 23, 1918, developed influenza, followed by pneumonia October 27, 1918, and complicated by empyema, left pleural cavity, hemolytic streptococcus type, November 2, 1918. There were four operations, prior to admission to Walter Reed General Hospital, with partial resection eighth and ninth ribs, left side.

Condition on admission to Walter Reed General Hospital: Patient anemic; weight, 131 pounds (normal weight, 168 pounds); poorly nourished; highly septic. Examination of chest showed sinus draining pus at the level of the ninth rib, mid scapular line, left chest. Radiograph revealed spindle-shaped cavity extending from the level of the ninth rib, posterior, to the third rib, posterior, about 4.5 cm. at its widest portion. There had been resection of parts of the eighth and ninth ribs, posterior, with regeneration of the bone joining the resected ends; marked collapse of left lung with thickened pleura from base to apex; pneumothorax most marked in the upper portion of the left chest; heart, aorta and mediastinal contents displaced markedly to the right. Clinical laboratory examination: Wassermann negative; urine negative; sputum negative for tubercle bacilli; red blood count, 4,000,000; white blood count, 7,000; hemoglobin, 85 per cent; culture from cavity showed streptococcus hemolyticus.

November 10, 1920, resection of 20 cm. of the third to sixth ribs, left sinus tract excised and the cavity laid wide open over this area; preparation for active dakinization. December 27, 1920, the lower part of the cavity was attacked and about 20 cm. of the seventh, eighth, and ninth ribs were resected. Crossbone formation with necrosis was found in this area. This part of the cavity being laid widely open, the whole of the cavity was now exposed to view. The cavity soon cleaned up under active dakinization, and the obliteration of the wound proceeded at a rapid rate. This obliteration was aided by linear scarifications of the visceral pleura at weekly intervals. The depth of the wound gradually increased largely by the re-expansion of the previously collapsed lung. April 27, 1921, the cavity was entirely obliterated in its lower aspect and the upper angle showed only a superficial wound, the floor of which was formed by the visceral pleura. A plastic operation was contemplated with excision of the scar tissue and the establishment of the continuity of the muscle bodies lying on either side of the old wound. The patient, however, considered himself practically well and requested discharge. Patient discharged June 3, 1921.

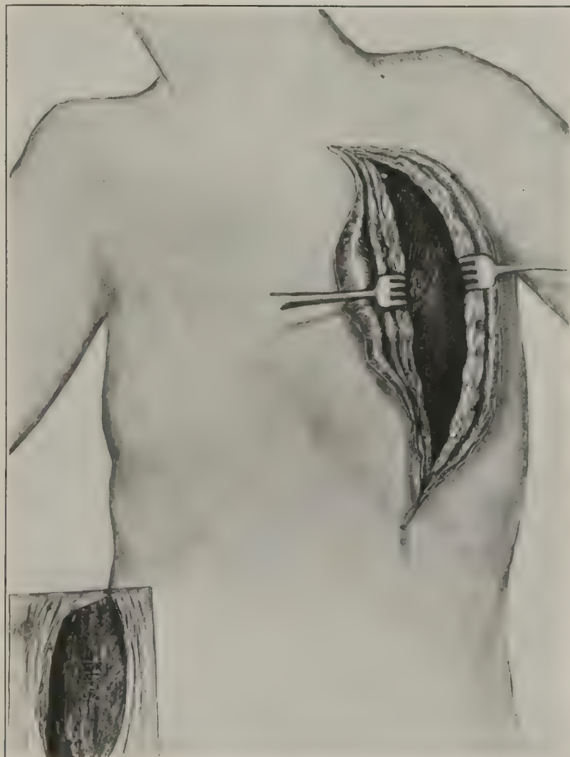

Fig. 132.—Case 39: Bronchial fistula persisting in a case otherwise prepared for closure.

Factors to be combated were hemolytic streptococcus present; osteomyelitis of rib stumps; marked collapse of left lung with thickened pleura from apex to base.

Case 39.—R. L. S., age 21 years. February 26, 1920, developed influenza, complicated by bronchopneumonia March 5, 1920, and by empyema, left pleural cavity, hemolytic streptococcus type, March 18, 1920. Aspirated six times. March 24, 1920, operation; intercostal thoracotomy, eighth interspace, anterior axillary line, with the institution of drainage and irrigation with Dakin's solution. August 12, 1920, operation: thoracotomy; resection of 10 cm. of seventh and eighth ribs, anterior axillary line, cavity left open for irrigation with Dakin's solution. September 24, 1920, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; poorly nourished; present weight, 115 pounds (normal weight, 130 pounds). Examination of chest revealed sinus discharging pus, anterior axillary line, left chest; pleurobronchial fistula present and a large cavity formation extending

up to second rib, anterior aspect of left chest; a large cavity formation noted extending from second rib to base with a capacity of about 500 c. c. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli; white blood count, 6,250; red blood count, 4,700,000; urine negative; culture from cavity showed hemolytic streptococcus and proteus. Blood pressure: Systolic, 132; diastolic, 74; pulse pressure, 58. Vital capacity reading, 1,600 c. c.

November 5, 1920, operation: resection of 20 cm. of fourth, fifth, sixth, seventh, and eighth ribs, left chest, midaxillary line, with the roof of cavity excised and pleurobronchial fistula exposed; skin inverted over muscles that were severed, and fixed over rib stumps to preserve the muscles for final closure and to render dressing less painful; cavity left open for active dakinization; December 1, 1920, operation: resection of 10 cm. of second and third ribs, anterior axillary line, left chest with a plastic closure of the upper aspect of cavity with a portion of the pectoralis minor muscle; the several superficial muscles and skin brought in apposition and sutured; the lower aspect of the cavity left open for drainage and dakinization. December 22, 1920, operation; enlargement of drainage opening in lower aspect of cavity and preparation of cavity for active dakinization. January 31, 1921, operation; resection of 10 cm. of eighth and ninth ribs, anterior axillary line, left chest; bronchial fistula closed by suture and implanting muscle over it; sinus tract excised. April 28, 1921, operation; mobilization of lung about fistula and closure of fistulous tract by means of purse-string suture; plastic closure of lower aspect of cavity, leaving ample drainage. September 29, 1921, operation; excision of scar and superficial ulcer over lower aspect of plastic closure. November 20, 1921, patient entirely healed, general condition excellent. Had taken on weight since his first operation; X ray showed total obliteration of all cavity formation and the lung well expanded. December 6, 1921, healed and in excellent physical condition; weight, 125 pounds; vital capacity reading, 2,300 c. c. Granted 60 days' leave. March 1, 1922, condition steadily improving. May 15, 1922, discharged, completely cured, after having been healed five months.

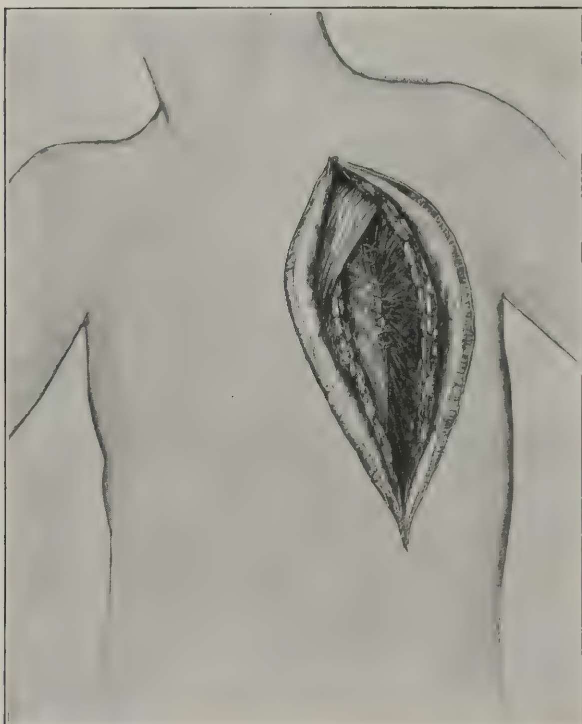

FIG. 133.—Case 39: A stage in the closure of the wound.

Factors to be combated in this case were hemolytic streptococcus present; osteomyelitis with rib sequestration; pleurobronchial fistula present.

CASE 40.—H. C. C., age 26 years. January 25, 1918, developed pneumonia; complicated by empyema, right pleural cavity, hemolytic streptococcus type, January 27, 1918. Aspirated three times. Received seven operations prior to his admission to this hospital with resection of the fifth to tenth rib, inclusive, right chest. Received active dakinization and continuous treatment. March 29, 1922, admitted to empyema service, Walter Reed General Hospital.

Condition on admission: Ambulatory case; fairly well nourished; quite septic; and slightly under weight. Examination of chest: Marked disturbance in contour of right chest, posterior lateral aspect, due to previous operative procedure. Sinus discharging pus seventh interspace, posterior axillary line and a narrow cavity formation extending from the fifth to the tenth rib, same line; a partial collapse of the right lung noted, and some osteomyelitis of the previously resected rib stumps; a regeneration with bridging and overlapping of the previously resected ribs.

Capacity of cavity, 300 c. c. Radiographic examination supported the above findings. Clinical laboratory examination: Wassermann negative; sputum negative for tubercle bacilli: white blood count, 13,700: red blood count, 4,280,400: hemoglobin, 75 per cent: urine negative: culture from cavity showed hemolytic streptococcus and staphylococcus aureus. Blood pressure: Systolic, 136; diastolic, 80; pulse pressure, 56. Vital capacity reading, 1,800 c. c.

April 10, 1922, operation; resection of regenerated rib stumps, from the fifth to the tenth rib, inclusive; entire cavity laid open; multiple fistulous tracts excised; skin inverted over covered superficial muscles and fixed; multiple scarifications of skin to cause relaxation along suture line; implantation of a portion of the deep fascia into the apex of the exposed tract: preparation of the entire cavity for active dakinization. May 17, 1922, operation; resection of a mass of regenerated bone in site of cavity and removal of an additional portion of the ninth rib, posterior aspect, with excision of sinus tract leading down under rib; entire cavity left open for continuous dakinization. June 7, 1922, operation; plastic closure by muscle and skin of entire space remaining following maximum lung expansion, with the implantation of a portion of the latissimus dorsi muscle into the space; muscle and skin brought into apposition by means of silkworm gut sutures; Carrel tube and rubber-dam drainage for 24 hours; multiple scarifications of skin to cause relaxation. June 20, 1922, entire structure healed; patient feeling well; lung well expanded and all cavity obliterated.

FIG. 134. -Case 39: Final result.

The illustrations following are photographs of some of the patients whose case records have been considered above. They are included in the chapter to show the degree of physical rehabilitation to which it was possible for them to attain.

REFERENCES.

(1) Annual Report of the Surgeon General, U. S. Army, 1920, 441.
(2) Special Empyema Reports. On file, Record Room, S. G. O., 710, Empyema (Walter Reed Hospital) K.
(3) Bunge, H: Ueber die Häufigkeit und Art der Nachoperationen an Amputationsstümpfen. *Beiträge zur klinischen Chirurgie*, Tübingen, 1919, cxvi, 705.

Fig. 135. Showing degree of physical rehabilitation attained in some of the cases described.

FIG. 136.—Showing degree of physical rehabilitation attained in some of the cases described.

Fig. 137. Showing degree of physical rehabilitation attained in some of the cases described.

SECTION II.

MAXILLOFACIAL SURGERY.

INTRODUCTION.

In the organization of the professional activities of the Medical Department during the World War the special branches of surgery which were devoted to the treatment of diseases, defects, and injuries of the head were combined for general supervision and coordination, in the Surgeon General's Office, under the title, "Division of Head Surgery." The component parts of this division were the sections of ophthalmology, otolaryngology, brain surgery, and plastic and oral (maxillofacial) surgery.

This section of the history will consider the surgical work done and the results attained by the maxillofacial specialists. In order that a clear understanding may be had as to the scope of maxillofacial surgery, the following instructions from the Surgeon General of the Army are quoted:[a]

> All cases shall be considered as maxillofacial in which there are injuries or diseased conditions of the bones of the face or jaws, wounds of the face, mouth, or neck, or any defects resulting therefrom with the exception of the thyroid, the nerve trunks, the eyes, and their adnexa.
>
> The following conditions shall be given special care by the maxillofacial section, viz:
>
> Depressed, otherwise distorting or unsightly scars in the region of the face, mouth, and neck; nonunion, fibrous, or other faulty union, and maladjustment of fractured maxillary or facial bones; perforations through the external walls of the maxillary sinus or the palate, and delayed healing in wounds of the face or floor of the mouth; trismus of the muscles of mastication or any other defect causing interference with the function of parts in association with the face, mouth, or neck.

In preparing this review of the professional war activities of the maxillofacial specialists it was considered advisable to combine and correlate the contributions of the individual officers of this service, thus avoiding the repetitions which inevitably would result from the publication, in a single volume, of their separate reports.[b] The compilers have endeavored to present the

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[a] Letter from the Surgeon General to Chief Surgeon, Hoboken, N. J., January 11, 1919. Subject: Classification of Cases to be Considered Maxillofacial. On file, Record Room, S. G. O., 730 (Surgery, Oral and Plastic).

[b] List of officers who contributed the reports and articles from which were obtained data for writing the history of the maxillofacial service: Vilray P. Blair, Lieut. Col., M. C., Senior Consultant in Maxillofacial Surgery; A. E. F., Chief of Section of Plastic and Oral Surgery, Surgeon General's Office; Consultant and Operating Surgeon, Maxillofacial Department, Post Hospital, Jefferson Barracks, Mo. S. D. Boak, Col., D. C., Chief of Dental Service, Walter Reed General Hospital, Washington, D. C. Roy L. Bodine, Capt., D. C., Walter Reed General Hospital, Washington, D. C. William T. Coughlin, Lieut. Col., M. C., U. S. Military Hospital No. 1, Paris, France. A. L. Dameron, Capt., D. C., U. S. Army General Hospital No. 11, Cape May, N. J.; Post Hospital, Jefferson Barracks, Mo. George M. Dorrance, Maj., M. C., Local Consultant in Maxillofacial Surgery, Beaune, France; U. S. Army General Hospital No. 11, Cape May, N. J. Henry S. Dunning, Maj., M. C., Base Hospital No. 115, Vichy, France. Milo B. Dunning, Capt., M. C., Assistant to Director of Physiotherapy, Walter Reed General Hospital, Washington, D. C. Joseph D. Eby, Maj., D. C., Walter Reed General Hospital, Washington, D. C. Robert H. Ivy, Lieut. Col., M. C., Local Consultant in Maxillofacial Surgery, Vichy and Clermont Ferrand Hospital Centers, France; Assistant to Chief of Section of Plastic and Oral Surgery, Surgeon General's Office; Consultant and Chief of Maxillofacial Service, Walter Reed General Hospital, Washington, D. C. J. B. Mann, Capt., D. C., Walter Reed General Hospital, Washington, D. C. Rea P. McGee, Lieut. Col., D. C., Mobile Hospital No. 1, A. E. F. A. L. Miller, Lieut. Col., D. C., U. S. A. General Hospital No. 2, Fort McHenry, Md. James B. Montgomery, Maj., M. C., Director of Physiotherapy, Walter Reed General Hospital, Washington, D. C. Herbert A. Potts, Maj., M. C., Local Consultant in Maxillofacial Surgery, Orleans, France. Stewart D. Ruggles, Maj., D. C., Chief of Dental Service, Hospital Center, Vichy, France. George C. Schaeffer, Lieut. Col., M. C., Assistant to Senior Consultant in Maxillofacial Surgery, A. E. F., Chief of Maxillofacial Service, U. S. Army General Hospital No. 2, Fort McHenry, Md., and Post Hospital, Columbus Barracks, Ohio. Ivan E. Smith, Capt., D. C., Base Hospital No. 15, Chaumont, France. Frank J. Tainter, Maj., M. C., Post Hospital, Jefferson Barracks, Mo.; and others.

material in such manner as to furnish a description of the various types of wounds, and of the complications encountered from the time of injury to the completion of treatment. In some instances the successive stages of the corrective procedure could be given more satisfactorily by means of pictures than by verbal description. Photographs and line drawings have been used freely throughout to illustrate or supplement the text.

It is fully realized that many officers whose names do not appear in the list of contributors to this section played an important part in the maxillofacial service. Any oversight in not mentioning each by name was wholly unintentional.

When we entered the war much work had already been done in maxillofacial surgery by our Allies, and grateful acknowledgment is made for the inspiration and experience gained by American maxillofacial and dental surgeons from the pioneer work of their confrères who were attached to the hospitals of the Allies, particularly to Hayes and Davenport, of the American Ambulance in Paris, to Morestin and Lemaître, of the French Army, to Kazanjian and Valadier, of the British Expeditionary Forces, to Gillies and his coworkers at Sidcup, and to Percival Cole of London.

CHAPTER I.

GENERAL CONSIDERATIONS.

The details of the organization of the Section of Plastic and Oral (Maxillofacial) Surgery of the Division of Surgery of the Head, Surgeon General's Office, and the plans formulated for the care of face and jaw injuries, are described in Volume I of this history.

In the preparation of plans for the conduct of the maxillofacial services two fundamental principles were involved: (1) The close cooperation of surgeons and dental surgeons; (2) the early institution and the continuous and systematic conduct of treatment. No difficulty was encountered in the cooperation of surgeons and dental surgeons, these officers working together with harmony at all times, under the general direction of the maxillofacial consultants, who maintained an effective liaison between the general surgical and the dental services.

The general principles underlying the early institution of treatment of wounds in general were not new, but their importance had been further demonstrated during the early years of the war. The Allies had placed their advanced hospitals nearer to the firing lines than had been done previously, and the systems of evacuation involved had been arranged, in so far as possible, to keep the wounded under proper surgical care at all times.

One of the chief difficulties encountered by our maxillofacial medical and dental officers was lack of the necessary equipment in the advanced hospitals. While this equipment had been secured, it frequently happened that lack of transportation, or other military necessity, prevented its arrival at the front hospitals when most needed.

Since the primary function of the mobile hospitals located close to the firing line was to prepare patients for evacuation to the rear, it was rarely possible to make either a segregation or a selection of types of cases. Early treatment of a special character by those qualified to administer it was subordinated, likewise, to this prime military necessity. Where it was not possible to have maxillofacial surgeons on the operating teams of hospitals or on the surgical units sent forward to the advanced hospitals for this early and definitive treatment, a competent dental surgeon was usually available. It was the duty of this dental surgeon during an evacuation period to render such assistance as was possible to surgeons who happened to be working on maxillofacial cases.

In the intermediate and base zones it was practicable to concentrate the maxillofacial patients in certain designated hospitals which had been equipped for their special care and to which selected maxillofacial surgeons and dental surgeons had been assigned. This segregation was found to economize personnel and equipment, and to add greatly to the efficiency of the treatment.

In the transfer of maxillofacial patients from France to this country it was found that great advantage was derived by placing them in groups on certain transports, with a specially trained dental officer assigned to look after them. This policy not only prevented any interruption in treatment, but also avoided unnecessary interference with the splinted cases.

Upon arrival in the United States the patients were admitted to the debarkation hospitals, where specialists were on duty, and then were promptly transferred to designated general hospitals equipped with adequate personnel and material for the final definitive treatment. When possible, these hospitals were selected with a view to permitting the wounded soldiers to be hospitalized within a reasonable distance of their homes.

In general, the records of the maxillofacial cases were fairly complete and may be regarded as unique in that, in a considerable percentage, the given case was followed from the advanced area through the successive stages of treatment to the final result.

Very few new principles as regards maxillofacial surgery were developed during the war, but the large number of wounds of this character encountered as compared to their frequency in civil life afforded unprecedented opportunities for demonstrating the advantages and the faults of the various operative procedures which had been devised. Based on the experience of surgeons of the allied forces, and from their own observations during our earlier engagements, our maxillofacial surgeons were enabled to draw certain conclusions which proved of the greatest value in the treatment of wounds of the face and mouth. It must not be understood, however, that it was possible in all cases to follow the precepts which were set forth. Indeed, owing to existing conditions, frequently it was not possible even to provide that a given casualty would receive the early and continuous treatment known to be desirable. But the contrast between cases in which such provision was made and those in which it was not was striking.

An important feature of the early treatment was the conservation of the vital forces of the injured man. The simple procedure of requiring a patient with an oral or pharyngeal wound to sit up, or if he must be recumbent, placing him with face down, was found to make it possible to bring alive to the hospital many who would have died on the way if permitted to remain in the supine position. A half-inch rubber tube passed through the mouth into the oropharynx gave a perfectly free airway in almost all cases.

The chief factor which delayed and complicated repair in maxillofacial wounds was sepsis. At a later stage of treatment complications arose from the displacement of tissue caused primarily by gravity and muscular pull and later by infiltration and scar contraction. In but few cases was the amount of tissue originally destroyed the dominant factor. The early restoration of the remaining tissues to approximately their normal positions, when done with due regard to surgical principles, combated not only primary and secondary displacements, but was the most effective preventive of sepsis. It was not reasonable to believe that all periosteum and osteogenetic cells in a section of bone were destroyed unless the covering of soft tissue was also completely devitalized; therefore, early splinting of the remaining fragments in their proper position, with provision against sepsis by suitable drainage, gave earlier and more perfect restoration than when the tissues were allowed to collapse and the sepsis to go uncontrolled.

In view of the fact that the tissues of the face heal better than those of almost any other part of the body, and are practically immune to the ordinary infections, while gas gangrene of the face, except in the orbit, is almost un-

known, débridement was not practiced on the face except for the removal of already devitalized tissue. Even the facial tissue, however, can not be expected to heal over a mass of comminuted infected bone without the provision of drainage. Some missiles caused a devitalization of tissue that precluded the restoration of circulation, but it was found that a certain amount of primary repair could be done in almost all face injuries even if it were only to follow Tuffier's advice to suture the mucosa to the skin to protect the raw surface.

The floor of the mouth and the submaxillary and submental regions were found to be peculiarly liable to indurating infection following battle wounds, and if one of the primary branches of the carotid had been divided, the more closely the wound approached the carotid region the greater was the danger. Therefore, except to anchor the tongue, no repair was advisable in this region. Above the lower border of the mandible, however, all soft tissues were repaired, if their condition permitted. It was especially advisable that the alæ of the nose, the angle of the mouth, the ear, the eyelid, and the lip be immediately repaired whenever practicable. Flaps of cheek, lips, chin, alæ of the nose, eyelid and ear that had lost part of their attachment rapidly retracted, and repair at a later period was always most difficult.

The removal of foreign bodies at the primary operation was regarded as advisable, but in certain cases it was found to be safer to insure drainage and to delay removal until such time as special skill and equipment were available and more tranquil surroundings obtainable.

When the necessary operative skill and the time were available, local anesthesia for operative procedures was regarded as adding a measure of safety, but in times of stress this was not practicable, and a general anesthetic skilfully given by the mask or by the intratracheal method added little danger in the majority of cases and possessed certain advantages. No patient was supposed to be sent to the hospital ward until a free breathing space was assured, hemorrhage controlled, and adequate drainage provided.

Secondary hemorrhage was always the result of sepsis, and the sepsis as well as the hemorrhage required treatment. When possible the bleeding vessel was identified and ligated, but in indurated tissue it was often better to ligate in the course of the vessel than at the bleeding end.

Sepsis about facial wounds was best controlled by drainage, frequently changed packs, or external dressings, and cleansing mouth washes were beneficial, but the Carrel-Dakin solution or other germicides were not well tolerated. Acute spreading infections rarely occurred when proper early treatment had been given, but in some instances erysipelas complicated improperly treated wounds. Ordinarily, incisions for the relief of sepsis were not made until pus was demonstrable, but the indurating infections of the floor of the mouth and submaxillary regions (Ludwig's angina), when spreading or embarrassing respiration, demanded immediate free incision. It was regarded as desirable to make all incisions for sepsis about the floor of the mouth from the skin surface.

The presence of a foreign body always aggravated the sepsis following a facial wound, the foreign body usually being a fragment of dead bone or the exposed root of a devitalized tooth. The removal of such bodies was promptly

followed by marked improvement, and union which had been delayed was hastened.

It was evident that as salivary fistulæ are dramage outlets, they could not be expected to heal unless the cause of the discharge was eliminated or another outlet provided. Furthermore, if the mucosa had become attached to the skin directly or by dense scar tissue, or if the walls of the fistula were actively diseased, the fistula would persist. With these conditions corrected, all fistulæ tended to heal spontaneously. Radical operations were rarely necessary; simply confining the jaws and applying a little pressure controlled all but a very few of the salivary fistulæ encountered.

Little that was radically new in the splinting of the jaws was brought out during the war. The Allies had demonstrated that the cast-metal splint was more easily made and more satisfactory than the swaged-metal or vulcanite splint with which we were more familiar. Many individual types were produced, but on the whole the simpler ones were the better. Many of them conformed to, or were modifications of, such old types as the cap splint of Hullihen, the open-bite splint of Gunning, the interdental splint, and the interlocking planes of Gilmer. The control of the ramus or its fragments brought out special devices.

One of the statistical tables, prepared in the Statistical Division of the Office of the Surgeon General, relates to the location of battle injuries by anatomical parts.[1] In this table the number of wounds sustained in the various portions of the face are given as follows:

Bones:	
Malar	64
Maxilla, inferior	1,123
Maxilla, superior	323
Nasal bone	77
Vomer	20
Zygoma	29
Parts:	
Chin	429
Cheek	2,870
Eye	2,184
Facial nerve	33
Parts—Continued.	
Lip, lower	126
Lip, upper	295
Lips, both	31
Mouth	101
Nose	670
Parotid	14
Tongue	45
Regions:	
Infraorbital	104
Orbital	69

These figures represent the total of wounds and not the number of men injured in the face; more than one wound was incurred by the same individual in a certain number of cases. In some instances the multiple wounds received by the same man would necessarily be included in a single operative procedure and hence were regarded by the maxillofacial surgeons as one case.

REFERENCES.

(1) Statistical tables, compiled in the Office of the Surgeon General. On file, Historical Division, S. G. O.

CHAPTER II

TREATMENT IN THE AMERICAN EXPEDITIONARY FORCES.

AT ADVANCED HOSPITALS.

The description of the treatment of gunshot wounds of the face and jaws as provided in hospitals located near the front is based on the work done at Mobile Hospital No. 1.[1] While there may have been slight differences in the method of caring for this class of patients in the advanced hospitals, the general routine was similar and the description given may be regarded as typical of all. This hospital, during the period of activities, was always stationed in a most advanced position, and it was frequently possible for it to receive patients as early as two hours after they had been wounded. Only nontransportable battle casualties were admitted to Mobile Hospital No. 1.

Nearly all of the patients admitted were suffering from shock to some degree; many were in a state of coma. In the great majority of shock cases in which there was a fracture of the mandible, the patient reacted when the jaw was set, shock, in these cases, usually being due to obstructed respiration. As soon as possible after the arrival the wounded were taken to the X-ray department and examined with the fluoroscope for foreign bodies, localization being registered by indelible pencil marks on the surface of the body.

When the patient was placed on the operating table, the face was usually covered with clotted blood and it was frequently necessary to have the anesthetic given before the slightest attempt could be made to clean the face. Among the first factors to be considered in connection with the treatment were the depth and shape of the wound and whether or not there was loss of tissue. Not more than 1 per cent of the patients with wounds of the soft tissues had a considerable loss of tissue other than in the direct course of the missile. Bone injuries in the maxillary region were more severe, especially when caused by fragments of high-explosive shells. Very few cases of bayonet wounds of the face were seen. The control of hemorrhage in recent wounds was not so difficult as was the control of secondary hemorrhage, but the secondary hemorrhage was a rare complication, largely because the mouths of the American soldiers as a rule were free from sepsis. Cases in which the parotid gland and Stenson's duct were injured presented the possibility of salivary fistula, and the plan in handling them was always to gather up the exposed portion of the duct or gland with sutures, to carry the sutures inside the mouth and to fix them there; then to close the face wound immediately so that the fistula, when established, would follow the suture line, and open into the mouth instead of on the face.

When possible, tracheotomy was avoided, but in some cases before, during, or after the operation, it was necessary to increase the air supply of the lungs, and tracheotomy was performed in a number of cases. Where patients were intubated immediately on admission to hospital, the anesthetic was administered through the tracheotomy tube,—a very convenient method.

Several cases of double fracture of the rami of the mandible, with the soft palate traversed, were encountered. In all these the men had been shot by snipers. In this type of injury the jaw dropped downward and backward and seriously interfered with respiration. If the jaw was set with the mouth closed, the swelling of the palate would completely stop respiration. It was necessary, therefore, to splint the mandible with the mouth open, but with the jaw very considerably thrown forward, to permit the patient to breathe while recumbent. This was done with a very simple emergency splint made from wooden tongue depressors and orthodontic wire (Fig. 1). Figure 2 shows the emergency splint applied, jaw thrown forward and mouth held open. All patients with this type of injury died unless treated early. They invariably reached the hospital in a sitting position, leaning forward, breathing with great difficulty, and extremely apprehensive. Those who became unconscious usually died en route, as breathing required great exertion on the part of the patient. The emergency splint always permitted the patient to breathe comfortably while lying down. He was fed with a rubber tube on a feeder through the forks of the splint. The levers were usually left on for three days and then removed, whereupon the jaws were closed with interdental wiring.

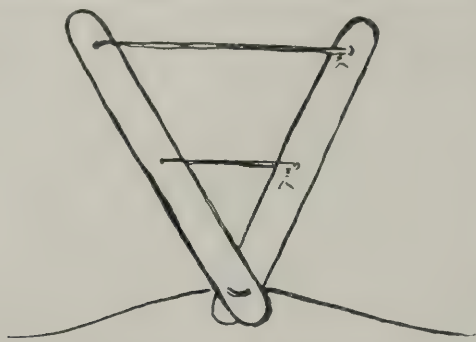

FIG. 1.—Emergency splint to permit breathing when the patient is lying down (McGee).

In fractures of the upper jaw, complete or partial, whether or not complicated with fracture of the mandible, the preferred early treatment was the use of the open-bite splint, such as was supplied by the Medical Department (Fig. 3), or the Kingsley type of splint used by the New Zealand troops. The Kingsley type was considered the more efficient. Chin bandages of any type were unsatisfactory. Union in fracture of the maxilla usually occurred much more promptly than union of the mandible; but when a prompt result was not obtained, an ununited fracture of the maxilla was more difficult to treat. In cases of traumatic cleft of the hard or soft palate the injury was repaired as soon as possible. It seemed desirable to avoid circumferential wiring or bone sutures when a good result could be obtained without them. Abscessed teeth, or teeth that were actually loosened in any line of fracture, were always removed.

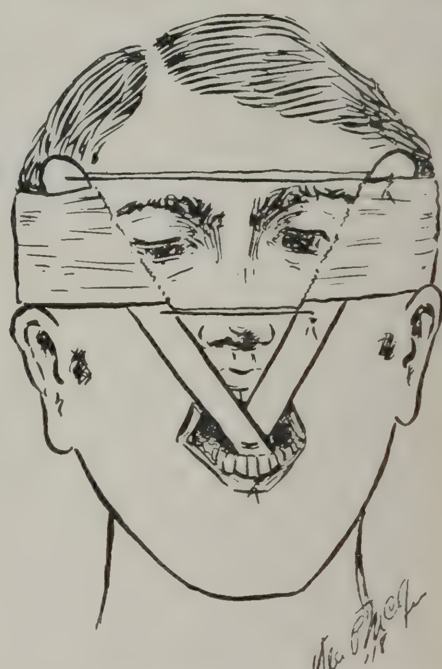

FIG. 2.—Emergency splint applied, jaw thrown forward and mouth held open (McGee).

It was seldom necessary to make incisions in the facial tissues in jaw cases, the wound of entrance and the natural opening of the mouth furnishing sufficient access and drainage. Stab wounds under the margin of the mandible, however, frequently were made to provide proper drainage. Rubber tubes were always anchored in the drainage area by means of sutures. Fractures of the jaws were temporarily splinted by wiring the lower teeth to the upper in occlusion with orthodontia wire, by a method which permitted rapid opening of the mouth in emergency (See Intermaxillary Wiring, p. 413.)

Fractures of the jaw were almost always complicated by wounds of the face. The jaw was first splinted as indicated above, and the facial wound then repaired. Gas gangrene did not occur in the region of the face, consequently débridement was not necessary. All live tissues and all bruised tissues which had sufficient vitality to recover were preserved, and the rich blood supply of the face made it possible for many bruised areas to regain their circulation.

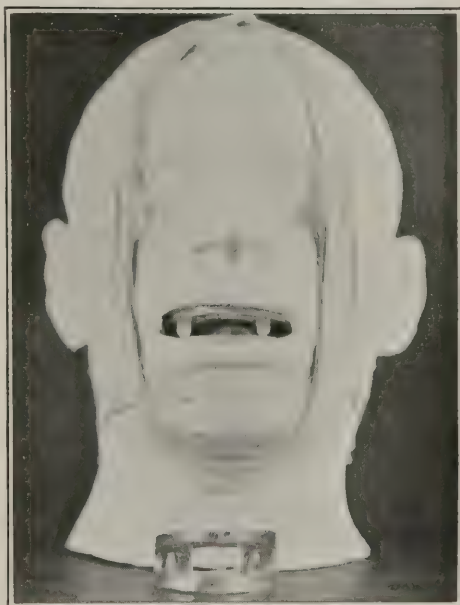

FIG. 3.—Aluminum open-bite emergency splint, for early treatment of upper or lower jaw fractures.

The contraction of the muscles of expression drew the lacerated tissues from their normal positions, and the greatest care was necessary to make the correct approximation of the facial tissue. Actual primary loss of tissue sufficient to require flap transfer was comparatively rare. The extensive loss of facial tissue from gunshot injury, so often seen in base hospitals, was more frequently due to shrinkage and adhesions of flesh fragments than to the actual loss from the primary wound. The routine procedure was to bring together the mucous membrane before the cutaneous surface was sutured. Tension sutures were used in all extensive injuries to support the approximating sutures and avoid scars and displacement.

When the nose was injured, it was repaired at once, if possible; and if the injury had resulted in a loss of bony structure, a modeling compound splint was used, when available, to prevent cicatricial displacement.

Patients with jaw splinted in either the open or the closed position were nourished with liquid diet given through a rubber tube attached to the ordinary hospital feeder. Many of the soldiers with their mouths splinted were unable to smoke. This was overcome by placing a glass of water or cup of coffee or chocolate where they could reach it, when, after wetting their lips with their fingers which had been immersed in the liquid, they were able to smoke as long as the moisture remained. This gave them a great deal of comfort. It was possible, also, in cases in which the lower jaw was fixed or missing, for the patient to hold one nostril closed and then, by moistening the other nostril and putting a cigarette in it, to inhale through it, thus smoking quite readily. The mouth was cleansed hourly with a warm salt solution. The 5 per cent eusol solution used by the British was very effective in these cases. A compressed air spray was helpful.

In wounds on the surface of the face as little dressing as possible was used.

Wounds of the tongue were numerous. Bone fragments, teeth, and bullets were frequently driven into and sometimes through it. In one case the tongue was more than two-thirds severed in the region of the molar teeth. These injuries were not difficult to repair with proper instruments, and in no case was there failure of union. Local anesthesia with procaine was used frequently. This gave satisfaction and resulted in a saving of time. One of the greatest difficulties with the limited equipment at hand, in the advanced hospital, was properly to cleanse the wounded mouth. In the treatment of these cases in a mobile hospital it was important that bone, mucous membrane, and skin be conserved, that drainage be carried to the extreme, and that all bone fragments with live periosteum be retained. Owing to the impossibility of providing proper care for mouth cases during the evacuation patients with these injuries often arrived at the base with a very considerable sepsis, which had not existed when they left the advanced hospital.

AT BASE HOSPITALS.

At the hospital centers one base hospital was usually provided with special facilities and personnel for the care of maxillofacial injuries. Here cases were received anywhere from two days to five months after injury, in the great majority of cases the injuries being not more than three weeks old. After the usual entrance preliminaries the matter of diagnosis was taken up jointly by the surgical and dental staffs, and this cooperation invariably yielded the best results. The wounds were examined and charted, X-ray examinations ordered, and, if the condition necessitated an immediate operation, the patient was sent to the operating room. Débridement, as understood in connection with wounds of the trunk and limbs, was not done on facial wounds. Only rarely was a patient admitted who seemed in danger of immediate death. When this did happen the cause was nearly always "suffocating phlegmon," or acute sepsis, due to the attempt of some one in a farther advanced hospital to secure healing by first intention without making ample provision for drainage. The trouble was rectified by the removal of sutures and cleaning out and packing recesses. The next consideration was removal, as nearly as possible, of all foreign bodies. It was soon found that practically all foreign bodies were sources of virulent infections, often manifesting themselves after some weeks had elapsed. All teeth in the line of fracture, broken-down roots, and pieces of teeth were extracted except teeth in a segment in which there would be danger of dislodging a fragment of live bone. In the latter case, after some union had taken place, it was possible to remove the necessary teeth without injury. The next consideration was readjustment of the injured parts, all pieces of bone being restored as nearly as possible to their normal contour, although the general contour of the bone was considered rather than the individual fragment. All live pieces of bone were saved. In the event of doubt as to their viability small fragments were left for several weeks when, if it was found that they had finally necrosed, a curettage was performed. For practically all operations, especially in the acute stages, general anesthesia was employed. This was absolutely necessary where relaxation was required. Very few cases of postoperative pneumonia were encountered.

When the patient had sufficiently recovered from the preliminary operation the matter of fixation of the fracture was considered. Early reduction of the fractures and fixation of the fragments with splints were preferred over slow reduction methods. The slower methods not only prolonged the final recovery of the patient but were more painful. No one particular type of splint was adapted to all cases, the one being chosen which the operator regarded as most suitable for the individual case. As a rule the reestablish-

Fig. 4.—Vulcanite cap splint for mandibular fractures.

Fig 5.—Cast-metal double close-bite splint, with fixation by bolts.

ment of correct occlusion took precedence over regard for apposition of fragments. Three types of splint construction were employed, vulcanite, swaged, and cast. The vulcanite splint (Fig. 4) was used occasionally in the simpler cases, but it was quite bulky and not adapted to more complicated ones. The construction of the swaged splint was found to consume too much time. The casting method was generally adopted because of its simplicity and easy adapta-

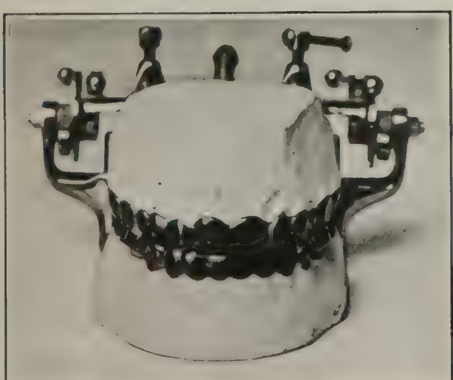

Fig. 6.—Same as Fig. 5.

Fig. 7.—Same as Fig. 6.

tion to all types of injury. The cast splint was better looking and could be made in one-third of the time taken to construct a swaged splint. The form of cast splint most commonly used was the double Gunning closed-bite splint, with fixation by bolts (Figs. 5, 6, and 7). In constructing a splint impressions of both mandible and maxilla were made of modeling composition, in sections if indicated, and the cast poured in plaster of Paris. Impressions of modeling composition were easily taken, were less painful than plaster impressions, and

were sufficiently accurate. The casts of the lower teeth were assembled in correct occlusion with the upper teeth. Anatomical occlusion was absolutely essential, therefore a Gysi or other frame was used. A wax pattern was carried over the crowns of the teeth and trimmed to the gingival line. These patterns were cast in sections, as extensive castings invariably contracted and were less accurate. The various sections were so made that after finishing they would drop into position without pressure; the connections were then made with silver solder. Bars or saddles were made of the same material and assembled much the same as removable bridge work (Figs. 8 and 9). It was essential that the thickness of the cast splint should be at least equal to 26 gauge to be rigid and serviceable. To insure accurate occlusion it was desirable that the occlusal surfaces should be ground thin; however, no untoward results were noted when this was omitted.

Fig. 8.—Cast-metal splint with vulcanite extension saddle for ramus.

In some few fractures, with little tissue loss, a single splint on the mandible alone was all that was needed. The great majority of cases called for rigid fixation and were connected to a similar appliance on the opposing jaw by bolt pins, as shown in Figure 5. The metal most used for casting was a French alloy known as maxillor, said to contain 80 parts of silver and 20 of copper.

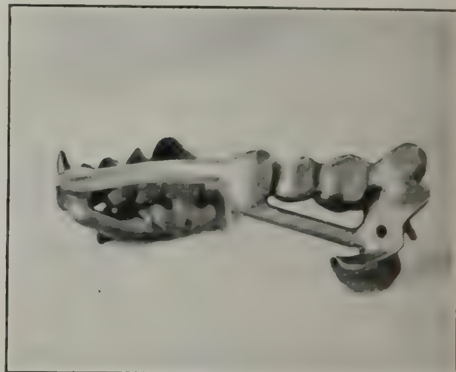

Fig. 9.—Cast-metal splint with bar and saddle.

One great advantage of the locking devices was the opportunity offered for examination and cleansing, as well as the safety of transportation on the ocean. The pins could be removed in case of nausea and vomiting. In placing these appliances in the mouth for the first time it was not unusual to encounter considerable difficulty in seating them properly. It was found that by the use of a bandage for one or two days they would be firmly seated and could then be cemented.

Fig. 10.—Swaged-metal cap splint with bars and vulcanite saddle for edentulous fragment.

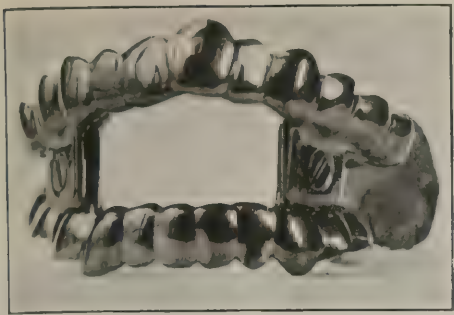

FIG. 11.—Cast-metal open-bite splint, with screw lock.

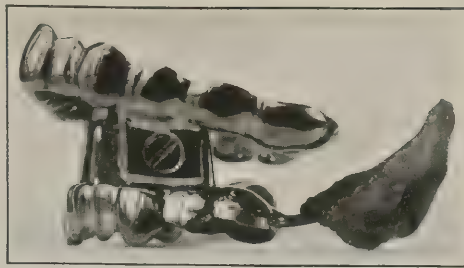

FIG. 12.—Same as Fig. 11, lateral view.

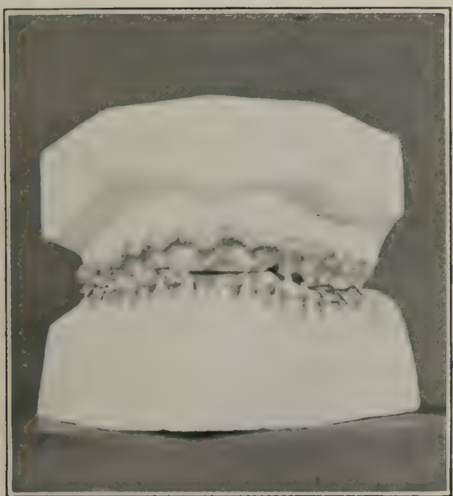

FIG. 13.—Swaged-metal splint covering upper and lower teeth, provided with hooks for elastics or ligature wires.

FIG. 14.—Same splint in open-bite position, with vulcanite blocks between upper and lower posterior teeth.

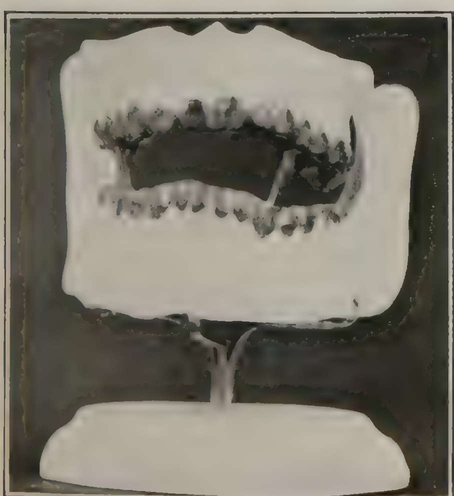

FIG. 15.—Cast-metal open-bite splint, with rigid bar connecting upper and lower portions.

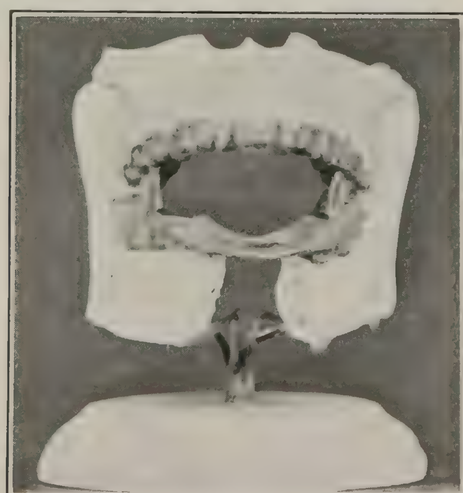

FIG. 16.—Cast-metal open-bite, with screw lock.

On rare occasions an open bite-splint was constructed (Figs. 11 and 12). These were used chiefly to prevent contracture of the jaws. The same object was attained by inserting vulcanite blocks between the upper and lower segments of the splint and securing them with ligature wire. In some cases swaged splints, provided with a series of hooks soldered on their buccal and labial surfaces, were made for the upper and lower teeth. The upper and lower sections were then secured together by means of ligature wires passing between the hooks (Figs. 13 and 14).

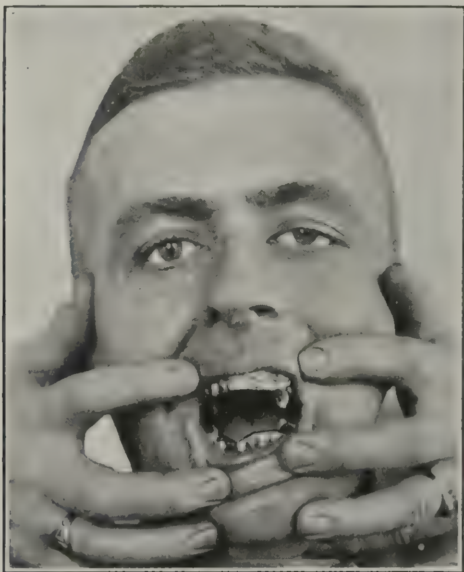

Fig. 17.—Metal open-bite splint, lock-pins removed.

In certain types of fracture it was impossible to hold fragments in a splint, for example, a fracture through both sides of the mandible at about the region of the mental foramen, with a possible loss of substance on one side in which the hyoid muscles exerted a downward and backward pull. For control of the middle fragment in these cases the operation of circumferential wiring was employed. It was adaptable to practically every class of fracture of the mandible except those behind the last tooth. It also solved the difficult problem of fracture where no teeth were present in the lower jaw, by using the operation in conjunction with an ordinary denture or a saddle of vulcanite or metal constructed to the ridge of the mandible. The operation consisted in making a very small incision through the skin at the lower border of the mandible and with a small curved trocar and cannula following the bone closely on its lingual side, piercing the mucous membrane of the mouth at about the gum margin. The trocar was then removed and one end of a 16 or 18 gauge silver wire passed up through the cannula. The cannula was withdrawn and, by means of the trocar, the wire was passed from the mouth downward close to the bone on the buccal or labial side, to emerge at the original skin opening. The other end of the silver wire was then passed up through the cannula, the cannula withdrawn, and the two ends of the wire brought up over the splint and twisted until the fragments were in their proper position. The ends of the wire were usually attached to a splint on the upper teeth, this providing fixation for the mandibular fracture. The circumferential wire was well tolerated and could be maintained for weeks (Fig. 18).

Fig. 18.—Radiograph of comminuted fracture of mandible showing fragments supported by circumferential wires.

Primary wiring of compound fractures of the mandible was discouraged, and only a few cases were attempted. In these it became necessary to remove the wires almost immediately because of the great amount of infection and necrosis produced. Several severe secondary hemorrhages also resulted. In a fracture of long standing, with no opening into the oral cavity, the wiring of bone could safely be attempted, with a chance of success.

For fractures of the upper jaw, with considerable displacement, the fragments were placed in their proper position and held there temporarily by means of an aluminum tray filled with soft modeling compound and with two bars running out of the angles of the mouth from the sides of the tray and curved backward over the cheeks. The bars were supported by a bandage or headgear over the vertex of the skull. Permanent fixation was later accomplished more

Fig. 19.—Aiguier adjustable headband supporting chin piece in emergency treatment of fracture of mandible.

Fig. 20.—Aiguier adjustable headband supporting chin bandage. This headband is equally useful as a means of attachment of Kingsley bars in treatment of fractures of the upper jaw.

accurately by fitting cast or swaged splints on the upper teeth, in combination with the headgear. A universally adaptable headgear was that shown in Figures 19 and 20. Until this was obtainable, the sweatband from a trench helmet proved very useful.

In conjunction with treatment of the fracture, attention was given to the injury of the soft parts. Owing to proximity of the wound to the mouth, infection was overcome with difficulty. Sepsis was controlled by free dependent drainage. The wounds were packed very lightly, the packing being changed daily, after irrigation. Various antiseptics were tried for cleansing the mouth and injured tissues, including Dakin's solution, potassium permanganate, and physiological salt solution. The solution was of little consequence provided irrigation was carried out at frequent intervals. In some hospitals at each patient's bedside was a small table on which stood a wide-mouthed bottle and an ordinary half-ounce syringe. All wounds of the mouth were syringed every

hour by day and every two hours by night. In other places the solution was placed in a douche can and reached the patient through rubber tubing and a glass nozzle. Shallow wounds beginning to granulate responded well to application of dichloramine-T. Wounds that were not sutured primarily, fell apart, causing them to seem much larger than they actually were. Facial supports, in bringing the flaps together and relieving muscular tension, aided future plastic operations and likewise were used, after plastic operations had been done, in supporting the sutures until repair had taken place. These supports were made by using ordinary hooks stuck to the skin with collodion on both sides of the wound and laced together by means of rubber bands (Fig. 21). Great assistance and support to the tissues was obtained by means of pressure pads attached with appliances to the teeth.

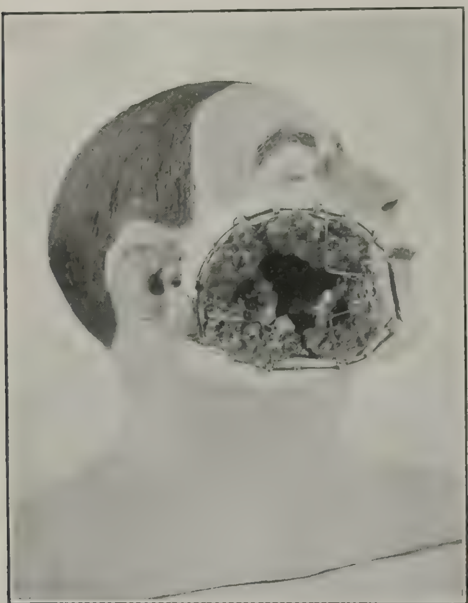

FIG. 21.—Representing facial supports in bridging wound flaps together by means of hooks stuck to the skin with collodion and laced together with rubber bands and spring wires.

Hemorrhage and shock were frequently encountered. The hemorrhage was always of the secondary type, the result of sepsis or of a foreign body in close proximity to a vessel. It was controlled by packing or by ligation of the vessel that was the source of the bleeding. The carotids or their primary branches were controlled by ligating at a distance. The shock cases were held in the advanced hospitals until their condition warranted removal. Quiet, heat, and intravenous infusion of normal saline solution were the prime factors in treatment of the few cases occurring in base hospitals.

Salivary fistula was occasionally seen as a complication of wounds of the face. The discharge of saliva usually came from the parotid gland itself and was only rarely due to an injury of Steno's duct. The gland cases were difficult to diagnose at first, owing to the suppuration present. As a rule these gland fistulæ were very small and closed spontaneously after fixation of the jaws with splints and placing the patient on liquid diet. There were no overseas cases of salivary fistula requiring treatment after returning to the United States.

Experience showed that extensive repairs of the soft tissues should not be undertaken until all infection had cleared up, as the bacteria lie dormant in the tissues for months, and a lighting up of infection might easily be induced by operating too early. In most cases, therefore, it was considered advisable to defer operations involving extensive flaps or bone grafts until the return of the patients to the United States. For the most part plastic operations were limited to plastic repairs of lesser extent and to cases in which it became necessary to free scar tissue in order to make the mouth accessible. Many of these lesser plastic operations were done under local anesthesia.

The sudden change of diet, together with conditions incident to injury, were carefully borne in mind in the feeding of these patients. Upon entrance

all patients were placed on liquid diet and the regular meals supplemented with a glass of eggnog or cocoa at least twice during the waking hours. This was especially appreciated at bed time. In spite of this routine the patient invariably lost weight during the first two or three weeks. As the cases improved or were splinted, the semisolids were substituted. This enabled the dietitian, a very important adjunct in this department, to prepare meats and vegetables in a food grinder. It was surprising how food thus prepared could be consumed through the spaces formerly occupied by teeth. The atmosphere of the ward soon changed when this semisolid diet was instituted, and the patient not only gained in weight but became better satisfied with his lot. A definite menu could not be established, as it varied with the season, the position of the hospital, and the ability of the mess officer to procure vegetables, fruit, and other articles. The diet was varied as to the essential elements and was changed as often as circumstances permitted. The menu given below illustrates the meals served in one day at Base Hospital 115, A. E. F.:

Breakfast: Oatmeal or Cream of Wheat, with milk and sugar; bread and butter and coffee; cornmeal mush.

Dinner: Bean, vegetable or beef soup; ground meat, mashed potatoes, ground spinach or kale; bread and butter; milk or cocoa; cup custard.

Supper: Mush and milk; bread and butter; cocoa.

Intermediate: 10 a. m., grape juice; 3.30 p. m., eggnog; 8.30 p. m., hot cocoa.

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(1) McGee, R. P.: The Maxillofacial Surgeon in a Mobile Hospital. *Journal of the American Medical Association,* Chicago, 1919, lxxiii, No. 15, 1114.

CHAPTER III.

TREATMENT AFTER RETURN TO THE UNITED STATES.

Between 800 and 900 of the men who incurred injuries of the maxillofacial region in the American Expeditionary Forces required hospital treatment after return to the United States.[1] The majority of these were eventually concentrated in hospitals where special equipment and personnel had been provided for their care. These hospitals were the following:[2] Walter Reed General Hospital, Takoma Park, D. C.; General Hospital No. 2, Fort McHenry, Md.; General Hospital No. 11, Cape May, N. J.; General Hospital No. 40, St. Louis, Mo. Later the post hospital at Jefferson Barracks, Mo., replaced General Hospital No. 40, and the post hospital, Columbus Barracks, Ohio., received cases transferred on closure of General Hospital No. 2.

The patients arriving from overseas for further treatment belonged, in general, to the following groups, according to the character of injury:

1. Compound comminuted fracture of the mandible in process of consolidation. Some of these arrived with splints, some without; all required observation until completion of union.

2. Compound comminuted fracture of the mandible with delay in union and healing of the soft parts due to the presence of sequestra, infected teeth in or near the area of fracture, or foreign bodies. These required incision and drainage, removal of sequestra, teeth and foreign bodies, and general treatment of sepsis, in addition to splinting.

3. Ununited fracture with loss of substance. In many of these cases the tissues had been healed for some time, and there was evidence that union would not take place by natural processes. These required bone grafting. In others, where the nonunion was due to infection or lack of fixation, the application of splints and the removal of all sources of infection often resulted in new bone formation and eventual solid union.

4. Healed scars involving the soft tissues alone, requiring plastic operation, excision of scar tissue and obliteration of the deformity by flap sliding fat and fascia transplantation, or other operative measures.

5. Fractures associated with more or less extensive destruction or laceration of the soft tissues of the cheek, lips, or chin. These, of course, required fixation of the fracture and correction of the soft tissue deformity. Frequently the upper and lower buccal and labial sulci were partially obliterated by adhesions of the mucous membrane to the bone, requiring division and removal of the scar tissue and the lining of the cavities thus produced with epithelium by skin inlay grafts. Many of these injuries were accompanied by trismus and fibrous ankylosis, requiring corrective measures.

6. Cases presenting extensive destruction of the upper jaw and perforations of the hard palate into the nose or maxillary sinus, requiring operative or prosthetic procedures.

7. Miscellaneous cases of injury of the nose, orbit, external ear, and other parts requiring plastic operation.

FRACTURES.

The statistical table recording the battle injuries by anatomical parts, compiled in the Office of the Surgeon General, places the number of fractures of the mandible at 1,123 and of the superior maxilla at 323.[1] Fairly accurate records are obtainable for in the neighborhood of 600 patients with fractures of the jawbones who required further hospital treatment after return to the United States, 445 involving the mandible and 155 the superior maxilla. In 36 cases both upper and lower maxillæ were involved.

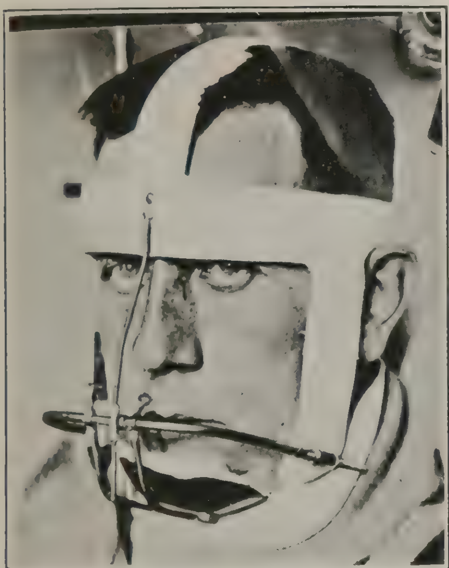

Fig. 22.—First splinting apparatus made by Major Valadier. Swaged-metal inferior dental-arch splint made to retain the correct occlusal width across the posterior lower teeth and attached to face bow for stability. Combined with external chin support.

Fig. 23.—Photograph of patient on arrival at Walter Reed General Hospital. Point of entrance of missile, healed.

The following table shows the site of fracture in 445 mandibular fractures:[1]

	Number.	Per cent.		Number.	Per cent.
Body	230	51.7	Condyle or coronoid	7	1.8
Symphysis	76	17	Multiple	34	7.6
Angle	53	12			
Ascending ramus	31	7	Total	445	....
Alveolar process alone	14	3.1			

The fact that more than half of the cases of gunshot fracture of the jawbones required no further treatment upon return to this country is striking testimony to the general excellence of the care they were given overseas, where most of the cases received early and constant attention in the form of reduction and fixation with respect to proper occlusal relationship of the upper and lower teeth, together with preservation of all viable bone fragments. The importance of early fixation and preservation of vital bone fragments is illustrated by two cases which were treated at the Walter Reed General Hospital. The first of these patients (Figs. 22–31) was wounded November 4, 1918, by a machine-gun bullet, which entered the left side of the mandible below the first pre-

molar tooth, making its exit on the opposite side at the same point, and causing a compound comminuted fracture of the symphysis. Received first splinting one week later, several viable bone fragments being preserved. Reached Walter Reed

FIG. 24.—Point of exit of missile, sinus draining pus from small bone sequestrum about lower right first premolar tooth. Sinus enlarged, curetted, and tooth removed March 12, 1919, healed March 15, 1919 (Figs. 22–23).

FIG. 25.—Showing extensive loss of alveolar process and teeth.

Hospital March 11, 1919; fracture ununited, but remaining fragments in good position. The second patient (Figs. 32–36) was wounded September 14, 1918, by a shell fragment, which caused a comminuted fracture of left side of the body of the mandible. Early fixation by intermaxillary wiring, followed by upper and lower swaged-metal splints, with teeth in proper occlusion and retention of vital bone fragments. On arrival at Walter Reed General Hospital, February 15, 1919, splints were in position, bone in process of consolidation.

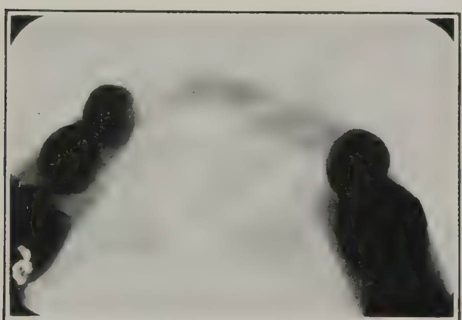

FIG. 26.—Radiograph showing fragments of vital bone. These fragments retained their vitality by being placed in a state of perfect rest, thereby preventing their exfoliation and the resultant need of a bone graft.

Contrast the foregoing with the results shown in Figures 37–43, where a large amount of bone was lost at the site of the injury and the two halves of the mandible were allowed to collapse and unite in malposition, with the result that later operative reduction and bone graft were required, prolonging the treatment by about one year.

METHODS OF FIXATION.

Intermaxillary Wiring of Teeth.

This procedure, which consisted of fixing the lower teeth to the upper in proper occlusion by means of wire ligatures, was the simplest efficient form of treatment of fracture of the mandible. Perhaps the chief outstanding advantage of wiring the upper and lower teeth in close contact was that this

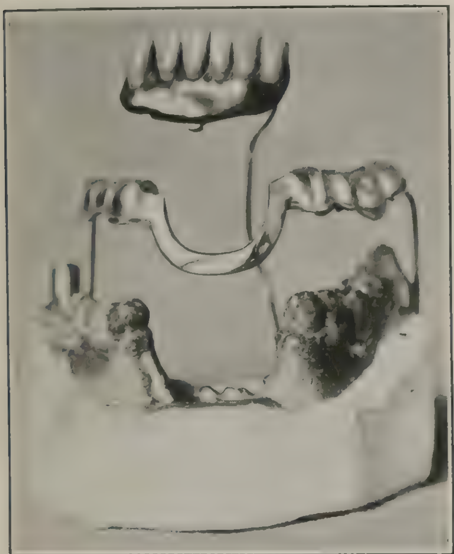

Fig. 27.—Showing details of cast-silver splint with heavy depressed bar and denture, made to immobilize lateral halves of mandible until anterior consolidation was complete (Figs. 22–26).

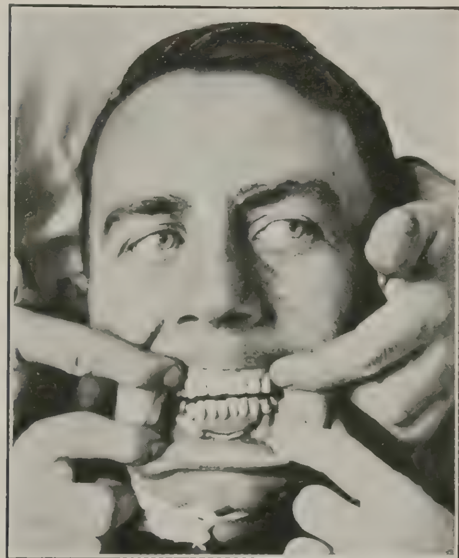

Fig. 28.—Apparatus in position.

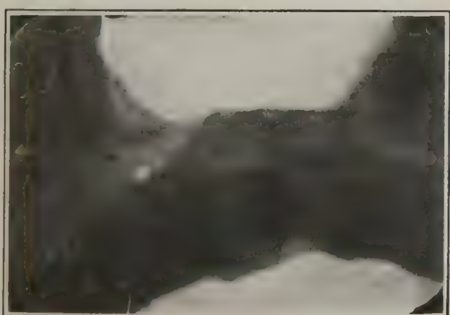

Fig. 29.—Radiograph showing consolidation of bone beneath splint. September 1, 1919, splint removed.

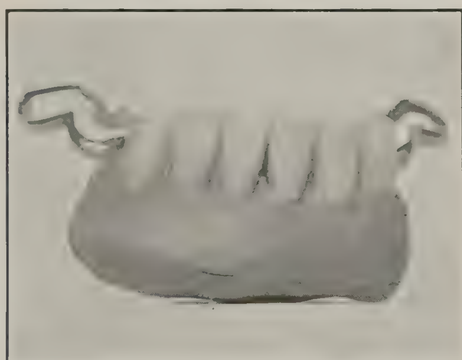

Fig. 30.—Permanent fixed-removable denture, cast clasps, base made of velum rubber.

plan of reduction of malposition, being founded strictly upon the basis of original occlusion, gave normal position to the fragments and absolute rest to all parts. Frequently, when even a thin covering of material was attached in the form of a splint between the upper and lower teeth, there was a slight change in the relation between the facets worn by the intimate contact of occlusion and this sometimes resulted in making the patient permanently very uncomfortable. With intermaxillary wiring, on the other hand, the upper and lower teeth being

bound in perfect relations, assurance existed that the functional relation would be restored perfectly. Other advantages of intermaxillary wiring were that it required only a few instruments and little material, and was an economy

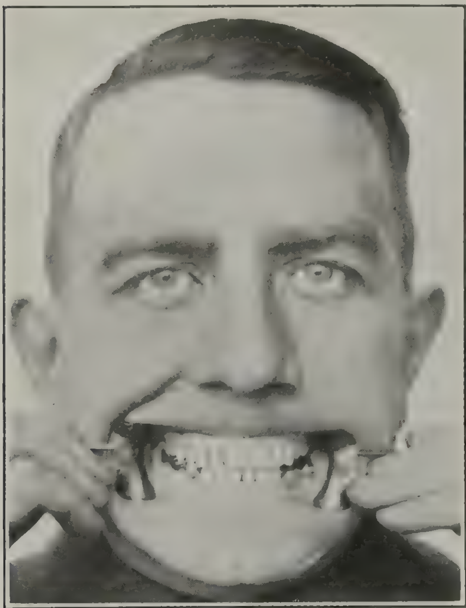

Fig. 31.—Completed case (Figs. 22–30).

Fig. 32.—Photograph of patient on arrival at Walter Reed General Hospital, showing healed scar at site of injury.

Fig. 33.—Swaged splints on maxilla and mandible, with hooks for ligature wires.

Fig. 34.—Radiograph, February 21, 1919, showing two fragments of bone at site of fracture, playing an important part in consolidation.

of the time which would be spent in the construction of splints. This form of treatment was used when sufficient sound teeth were present in the upper and lower jaws, and when the occlusion was fairly good. It had the disadvantage

that the jaws were locked together during treatment, which in some fractures with sound teeth in each fragment could be avoided by the use of a splint on the mandibular teeth alone. Intermaxillary wiring could not be used in some

Fig. 35. Mouth after removal of splints (Figs. 32–34).

Fig. 36.—Dentures in place.

Fig. 37.—Healed wound of exit.

Fig. 38.—Radiograph showing malunion of left side of body of mandible.

cases where the teeth were few, or were loose from pyorrhea, or where the occlusion was poor. In extensive comminuted fractures, with much infection, in which fixation had to be maintained for many months, splints were usually preferable. The wires tended to loosen or break, and required readjustment

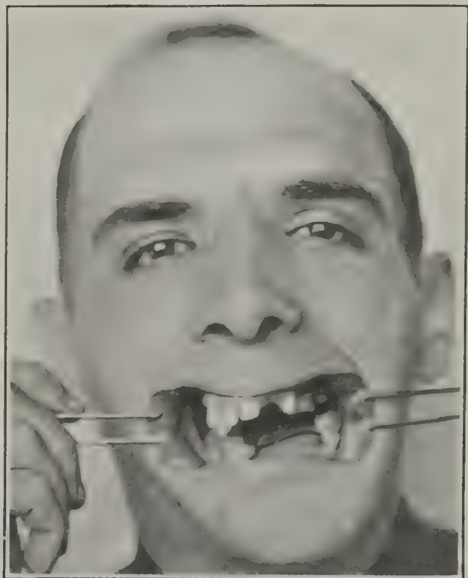

FIG. 39.—Showing malocclusion due to collapse of fragments (Figs. 37–38).

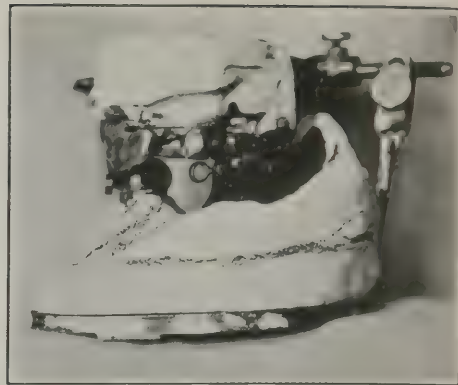

FIG. 40.—Cast-metal splint made in two lower segments and one upper segment, with lock-pin attachment. Splints inserted prior to corrective osteotomy.

FIG. 41.—Radiograph after osteotomy and fixation of fragments in proper relation to upper jaw. Note space at site of fracture.

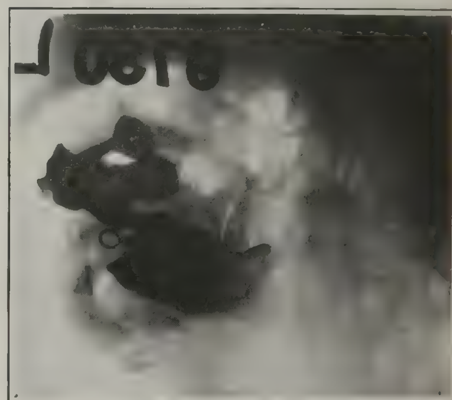

FIG. 42.—Radiograph showing osteoperiosteal graft, which was necessary to span the gap.

FIG. 43.—Radiograph showing bone regeneration three months after graft.

from time to time. It was sufficient to support the mandible in normal occlusion with the upper jaw by wiring the upper and lower teeth at three or even two points, whether the fracture was within the line of the teeth or at the angle or ramus. The wiring was designed to be easily inserted, easily tightened, and free from projection of the twisted ends sufficient to cut into the soft tissues of the mouth.

In the method commonly employed, individual wires are twisted very tightly about the cervical constrictions of two upper and two lower teeth on each side of the arch; the twisted ends from the upper teeth are connected with those of the lower and tightened in the form of a cross tie, or all of the wires are twisted together. If these wires are tightened sufficiently they are greatly weakened at the point of the twist, and breakage is very liable to occur, in which event the entire operation has to be begun over again. In wiring between four teeth, eight ends of wire are presented to be twisted together, which usually makes a large button of wire which has to be covered with cement or gutta-percha for protection of the lips. When these wires are loosened by the natural forces of the mandible pulling against them, they can rarely be tightened without breakage. If it becomes desirable, in an emergency or for any reason, to open jaws, it is difficult to cut the wires loose and the entire wiring process has to be repeated later. Unless teeth which are standing alone have to be used, this method of employing separate wires around individual teeth is never necessary.

Fig. 44.—Making the eyelet.

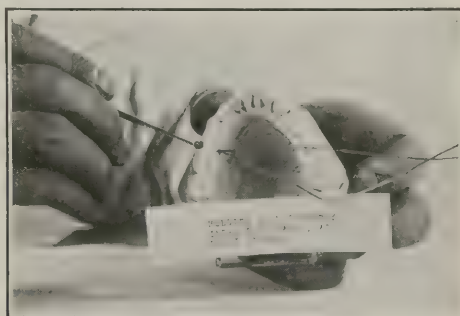

Fig. 45.—Holding eyelet deeply interproximally, at right angles.

The following method of intermaxillary wiring, a modification of that originally used by Col. Robert T. Oliver, Dental Corps, United States Army, developed by Maj. J. D. Eby, of the Dental Corps, and used extensively at the Walter Reed Hospital,[3] has eliminated all the objections of other designs. The largest-sized wire, which would pass freely through the interproximal spaces, was considered most suitable for this purpose; also, it needed to be soft enough to be intimately adaptable and tough enough not to break easily. The larger size of Angle's brass ligature wire or 22 G pure annealed copper wire were most suitable. The instruments required were a pair of hemostatic forceps, a pair of short-nosed scissors, and tenaculum or small hook-shaped instrument. In preparation of the wire a 1-foot length was folded around a small-end instrument and a loop pinched into the form of an eyelet, as shown in Figure 44. After selecting the teeth to be wired in pairs, the ends of the eyelet wire were inserted from the buccal surface beneath the point of interproximal contact as shown in Figure 45, between the lower left second pre-

molar and first molar. One end was then drawn through around the anterior tooth and the other end around the posterior tooth, on to the buccal aspect (Fig. 46). This process was repeated on corresponding upper teeth. Then the ends of the wire, in the case of the lower teeth, were twisted together with the eyelet projecting below the horizontal strand, as shown in Figure 47. In the case of the upper teeth the eyelet projected above the horizontal strand. In this way the eyelets were prevented by the horizontal wires from coming too close to each other when subjected to the strain of the connecting wire. It was important that the eyelets did not project from the interproximal space any farther than necessary to permit the passage of the connecting wire. In twisting the ends of the wire, the first turn was made as tight as possible by grasping the ends with the hands. This distributed the strain, thus avoiding breakage. If further tightening was necessary, it was done by grasping the ends of the wire with the hemostatic forceps, drawing the wire away from the tooth, and twisting carefully at the same time. The ends were then cut off short and bent in so as not to irritate the lips. The selected teeth on the opposite side of the mouth were then treated in the same manner, and if desired a third set of teeth was similarly wired, giving three points of suspension (Fig. 48). The upper and lower eyelets were then connected by passage through them of a third, connecting or tie wire (Fig. 49), the teeth were brought into occlusion and the ends of each connecting or tie wire twisted

Fig. 46.—Passing ends around approximating teeth.

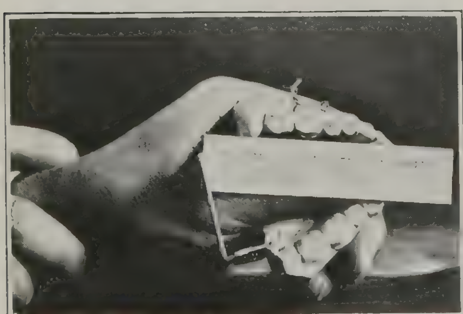

Fig. 47.—Twisting ends remote from eyelet. Above eyelet in lower, beneath eyelet in upper.

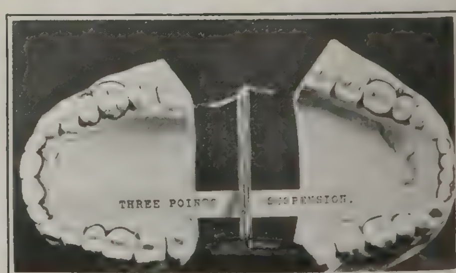

Fig. 48.—Three points suspension.

together (Fig. 50). In some cases of displacement the desired movement of a fragment to restore proper occlusion could be produced by placing the upper eyelet in a position anterior or posterior to that of the lower eyelet, as the case might be. Complete reduction was not invariably brought about immediately on placing the wires, but generally occurred on taking up the slack of the connecting wires after twenty-four hours.

A great advantage of this method was that, if one wire broke, it could be replaced without disturbing the other eyelet wires. If a patient was to receive an anesthetic, the eyelet wires were placed before the operation, and the jaws were fixed with the tie wires after the danger of nausea was passed. The tie wires could be cut at any time in order to test the fracture, and if it was found that consolidation was not complete they could be immediately replaced without repeating the process from the beginning. Figure 51 shows this method applied in a case of fracture in the region of the angle of the mandible. It was successfully used in many such cases in which conditions were favorable, and even as a means of fixation during bone grafting as will be shown later. (See Figs. 85, 104, pp. 433 and 438.) The slight motion of the jaws due to loosening of the wires, as compared to the absolute rigidity of splints, was regarded as an advantage late in the treatment of fractures, as it tended to stimulate bone regeneration.

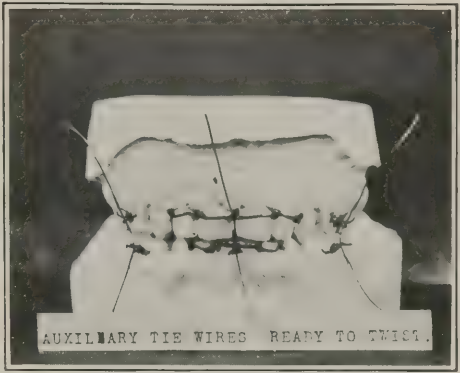

FIG. 49.—Auxiliary tie wires ready to twist.

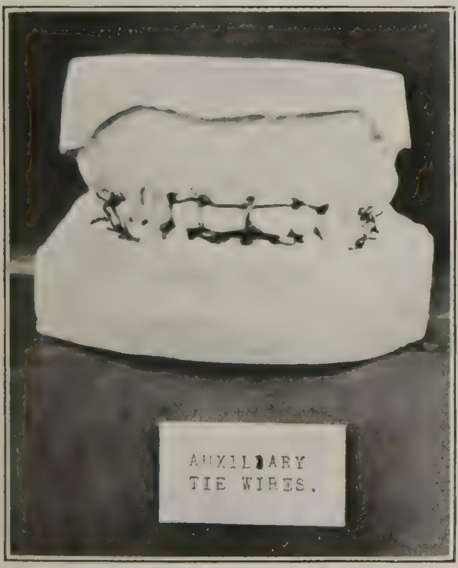

FIG. 50.—Auxiliary tie wires twisted.

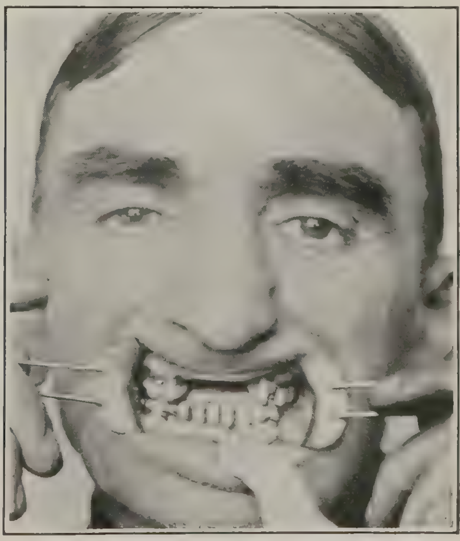

FIG. 51.—Intermaxillary wiring applied to case of fracture.

SPLINTS.

In the majority of cases of gunshot fracture of the mandible, complicated, as they were, by extensive comminution and wide displacement of fragments, sepsis, and destruction of teeth, necessitating prolonged treatment, some form of dental splinting was desirable. At the various maxillofacial centers, personnel and equipment were such that splints could be prepared and inserted within a few days after the arrival of the patient at the hospital. The technique generally adopted was to cast the splints in metal. A cast splint was constructed more quickly and accurately than one that was swaged. The old

vulcanite gutter splint was never used, as it was bulky, difficult to keep clean, and not so strong as the metal splint. Vulcanite, however, was frequently used for certain special removable attachments and prosthetic replacements. The metals most commonly used for casting were coin silver, to which a little copper was added, and aluminum. The form of splint employed varied, of course, with the needs of the case. In fractures of the body of the mandible, with two or three sound teeth in each fragment, it was often possible to give adequate fixation by means of a simple cap splint on the lower teeth alone. This had the great advantage of permitting the jaws to function during consolidation, promoting better nourishment of the patient, and stimulating bone growth. In other cases, with sound teeth in each fragment, but in which the fragments were displaced and joined by fibrous tissue, e. g., in symphysis fracture, it was necessary to construct the cap splint in sections, cement one on each fragment, and then, after reduction, to unify the two parts of the splint by means of a bolt or other device. (See Figs. 61–64, p. 424.)

A very useful form of splint for fractures with loss of substance in the molar region, in which one molar tooth remains in the posterior fragment was that shown in Figures 95, 96, and 97 (p. 437). This splint was made in two sections, one consisting of a cast-silver cap for the teeth in the large fragment; the other is composed of an Angle's band, fitting on the molar tooth in the posterior fragment, furnished with traction screw and locknut, which, when attached to the other section of the splint, could be used to force the ramus of the mandible downward and backward to restore the normal length of the injured side. On the buccal aspect of the cast cap on the sound side of the jaw there could be soldered a flange after the design of Gilmer, to preserve the natural occlusion without the need of locking the mandible to the upper jaw.

For fractures with sound teeth in only one segment, or at the angle or in the ramus behind the line of the teeth, or in any case where sufficient stability would not be gained by a mandibular splint alone, it became necessary to immobilize the mandible against the upper jaw by means of cast-metal cap splints covering the upper teeth as well as the lower. The upper and lower sections were cast separately and, after being mounted on an articulator in correct occlusion, were furnished with segments of square tubing soldered to the buccal aspect on each side for the reception of lock-pins or bolts to lock the upper and lower portions together. Very few intermaxillary splints were made with the upper and lower portions permanently soldered together. By removing the lock-pins it was possible to open the jaws readily whenever it became necessary, for examining the fracture or for any other purpose. (See figs. 5–7, p. 403.) These splints were generally made with the closed bite, though some operators preferred the open bite to prevent contraction in case of wounds of the soft tissues of the cheek. (See Figs. 11 and 12, p. 405.)

In many cases of fracture in the region of the angle, efforts were made to overcome the upward and forward displacement of the ramus fragment by means of a vulcanite saddle resting on the mucous membrane covering the anterior border of the ramus and extending backward from the main portion of the upper or lower splint. (See Figs. 119, 120, p. 443.) As a general rule, these saddles were not well tolerated, pressure ulceration and pain requiring their

removal after a short time. Another scheme for retaining the ramus in position, first employed by Pickerill,[4] was to drill a small hole in its anterior aspect through the mucous membrane of the mouth for the reception of a sharp heavy wire spike passing backward and downward from the upper splint. The wire was threaded to tubing soldered on the upper splint so that the required amount of extension could be obtained. A flange was soldered near the point of the wire to prevent undue penetration of the bone.

Coughlin[5] successfully employed in several cases an operative procedure for the control of the ramus fragment. Under local anesthesia, an incision 1 inch in length was made parallel with the fibers of the facial nerve which goes to the frontalis and upper half of the orbicularis palpebrarum muscles and extended only through the skin. The upper one-quarter of it overlay the zygoma, the remainder reached from one-half to three-quarters of an inch below it. A needle or probe was passed close to the zygoma, down through the masseteric fascia and the masseter muscle until the coronoid was felt. A closed pair of scissors was passed alongside this probe until the point of the scissors rested against the coronoid, when the scissors were opened, splitting the fibers of the masseter from the zygomatic border downward for an inch. Two small strong retractors were passed into this slit and, holding their ends firmly against the coronoid, retraction of the split masseter was made and the scissors withdrawn. An assistant passed his finger into the mouth and made reduction of the ramus. He then held the fragment reduced while a hole was drilled through the tip of the coronoid as close to the edge of the zygoma as possible. An ordinary wire nail with a thin flat head, about one and a half inches long, and of a size to exactly fit, was passed straight through the hole until its head impinged on the outer surface of the zygoma. If turned up very slightly its point soon came in contact with the under surface of the skull and it might not go far enough. When properly passed, the nail effectively prevented the coronoid from rising, as the nail caught at one end under the zygoma and its point came in contact with the base of the skull. The skin was closed with a figure-of-eight silkworm gut through the masseteric edges and the overlying structures. The nail was readily removed after four weeks.

TREATMENT OF UNREDUCED MANDIBULAR FRACTURES BY GRADUAL OR RAPID REDUCTION.

Owing to the transfer of the patient from one hospital to another and to the lack of consistent treatment, early complete reduction in terms of occlusion with the upper teeth was not maintained in certain mandibular fractures with loss of substance. This resulted in collapse of the fragments with the ensuing union ranging in character from loose fibrous to firm bony, and with complete disruption of occlusal relationships. The treatment of these cases at their final destination in the United States varied according to the firmness of the union and the amount of bone lost. In cases of loose fibrous union with only slight loss of substance, it was sometimes possible to bring about slow reduction to normal occlusion by means of expanding devices. Splints were prepared in two sections, one for each fragment, connected by a jackscrew, and the fragments thus slowly separated. In several cases of small loss of substance, particularly in the region of the symphysis, after slow reduction

and fixation had been practiced for some time, spontaneous bone regeneration and union occurred (Figs. 52–55). In other cases treated in this manner, no spontaneous union followed, and it was necessary to graft (Figs. 56–58). In fractures with pseudarthrosis behind the last tooth, the deviation of the large fragment toward the affected side was sometimes gradually overcome by the use of intermaxillary elastics attached

FIG. 52.—Symphysis fracture with fibrous union treated by gradual expansion.

FIG. 53.—Cast-metal cap splint with segment for each half of mandible, connected by expansible jackscrew.

FIG. 54.—Same as Fig. 53, mounted on cast.

FIG. 55.—Same patient after expansion and union of fracture, dentures inserted.

to bands on the upper and lower teeth (Figs. 59 and 60). After the occulsal balance had been restored, the jaws were fixed and the case was ready for bone grafting.

FIG. 56.—Expansion apparatus for symphysis fracture, consisting of overlapping bars with holes for the passage of ligature wires.

FIG. 57.—Showing details of expanding splint for symphysis fracture, provided with lock-pin for fixation after reduction.

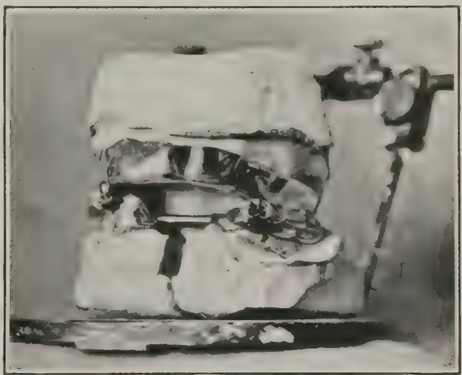

FIG. 58.—Same as Fig. 57, assembled.

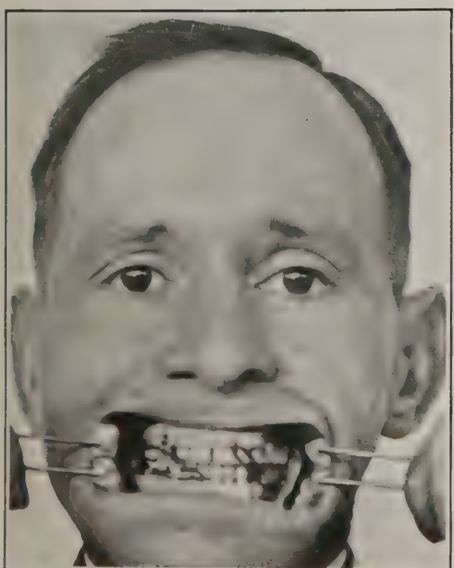

FIG. 59.—Deviation of lower teeth to affected side in fracture with loss of substance of left body of mandible.

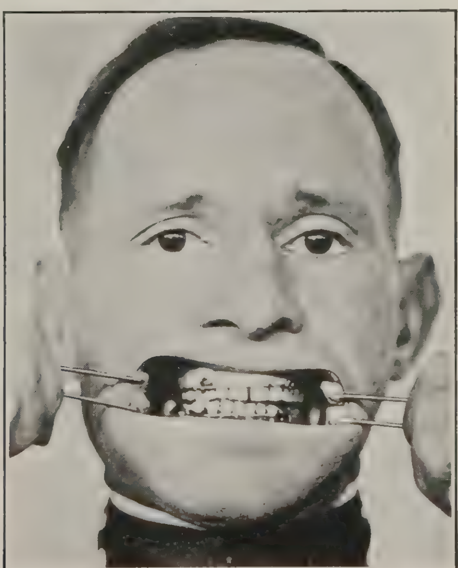

FIG. 60.—Same case gradually reduced by intermaxillary elastics.

FIG. 61.—Fracture with loss of substance with union in malposition.

FIG. 62.—Cast-metal sectional splints applied before operative reduction.

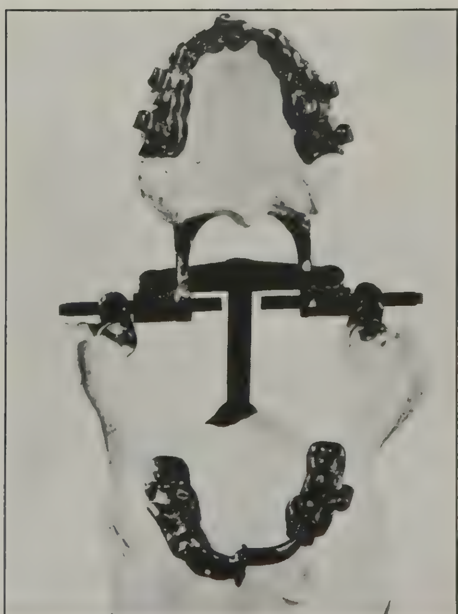

FIG. 63.—Sections of lower splint held in place by rigid bar after operative reduction.

FIG. 64.—Lower portion of splint attached to upper by means of lock-pins.

Where a firm malunion had occurred, or where there was a large loss of bone substance, osteotomy through the line of union, with rapid reduction and fixation by insertion of a previously constructed splint, was the method chosen. The splints were made in sections, one for each fragment, as in the slow reduction method, each section being furnished with a lock-pin attachment for fixation in occlusion to the upper teeth, after reduction, or the two sections, in some cases, were connected by a removable rigid bar, to be inserted after reduction (Figs. 61–64). The osteotomy was usually performed by a Gigli wire saw introduced through a small incision beneath the lower border of the jaw. (See technique of circumferential wiring, p. 406.) After the mouth and skin wound had completely healed, the gap between the fragments was filled with a bone graft. (See Figs. 37–43, pp. 415 and 416.)

Figure 61 illustrates the deformity in a case of fracture with loss of substance from the right central incisor to the left second premolar, in which

Fig. 65.—Gunshot wound of left cheek resulting in opening between mouth and maxillary sinus.

Fig. 66.—Shows opening into maxillary sinus.

collapse and union in malposition had occurred. Cast-metal splints for upper and lower teeth were prepared, separate caps being made for the two segments of the lower jaw. Figure 62 shows the splints applied to the casts before reduction. Reduction was accomplished after dividing the line of union with a Gigli saw. Figure 63 shows the fragments reduced and the two segments of the lower splint held in proper relationship by means of a rigid connecting bar. Further stability was given by connecting the lower sections of the splint with the upper by means of lock-pins which fixed the teeth in occlusion (Fig. 64).

LATE TREATMENT OF FRACTURES OF THE UPPER JAW.

Most of the cases of upper jaw injury requiring treatment after return to the United States resolved themselves into defects in the hard palate, alveolar process, and external facial contour. The problem of restoring continuity for nonunion, as of the mandible, did not enter here. The questions to be solved

were the closure of communications between the oral cavity and the nose and maxillary sinus, the restoration of the functions of mastication, deglutition and speech articulation, and the cosmetic appearance.

FIG. 67.—Obturator-denture inserted to cover defect and supply lost teeth.

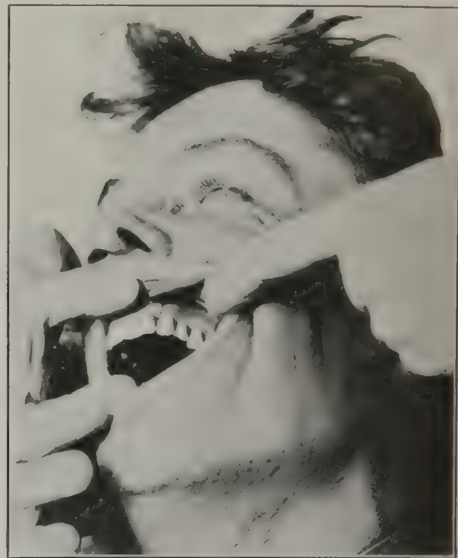

FIG. 68.—Same appliance in mouth.

FIG. 69.—Complete loss of the premaxillæ and upper teeth.

FIG. 70.—Recession of upper lip due to loss of alveolar process and teeth.

PALATAL DEFECTS.

The palatal defects ranged from complete loss of bone and soft tissues, converting the oral and nasal cavities into a common chamber, to small fistulæ connecting the mouth with the nose or the maxillary sinus. Most of the large palatal defects required closure by vulcanite prosthetic pieces attached by means of clasps to the remaining teeth, and extensions into undercuts or

crevices in the nasal chamber. These obturators also artifically supplied missing teeth and, when necessary, restored facial contour. Figure 65 illustrates the case of a man shot through the left cheek, with a resultant defect of the alveolar process opening into the maxillary sinus (Fig. 66). Figure 67 shows the obturator denture inserted to cover the defect and to supply the lost teeth. Figure 68 shows the same appliance in the mouth.

FIG. 71.—Cast showing defect and opening into nasal chamber.

FIG. 72.—Obturator-denture made to fill defect and supply lost teeth.

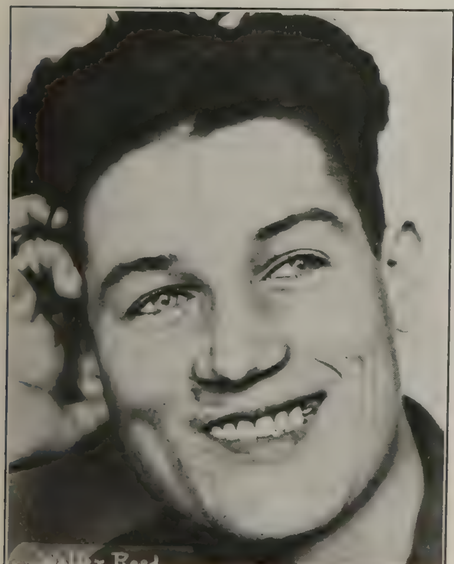

FIG. 73.—Denture in place (Figs. 69–72).

FIG. 74.—Profile view showing restoration of contour.

Figure 69 shows a complete loss of the premaxillæ and anterior upper teeth. There was a large opening into the nasal chamber which it was considered inadvisable to attempt to close by surgical operation. Figures 70–74 illustrate the further progress of this patient. In some cases the obturators were made in two or more sections. (See Figs. 212–213, p. 480.) Other gaps of considerable extent were closed by flaps from the palate, the mucous lining of the cheek or lip, or by skin-flaps introduced into the mouth from the neck.

For the closure of oral openings through the alveolar process into the maxillary sinus, Dunning[6] advocated the following operation: As shown by the illustrations (figs. 75–78), a palatal flap was taken, extending from the median line at the junction of the hard and soft palates anteriorly to about opposite the premolar teeth. The flap was thoroughly separated from the palate down to the periosteum, but the latter was not disturbed, as this

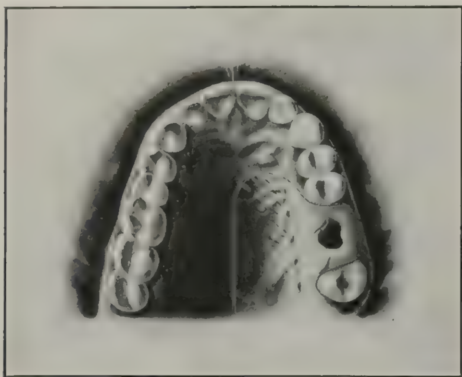

FIG. 75.—Outline of palatal flap to close opening into maxillary sinus.

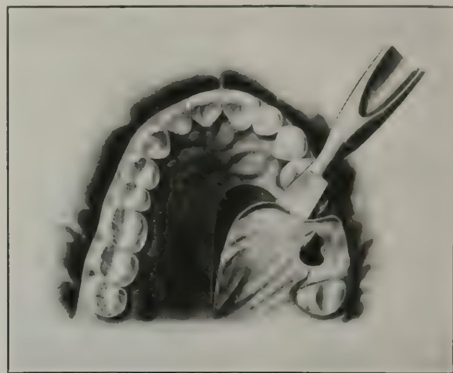

FIG. 76.—Flap separated from palate and carried over opening.

allowed for the better granulating in of the defect caused by the sliding of the flap over the opening to be closed (Fig. 75). The flap was very thick and, having at its base the anterior palatine artery, was well nourished. The next step was to free the outer edge of the flap, and to free the opening to be closed of all soft tissue down to the bone. Sharp edges of bone were smoothed off, and often the alveolar process was trimmed so that the flap would more than

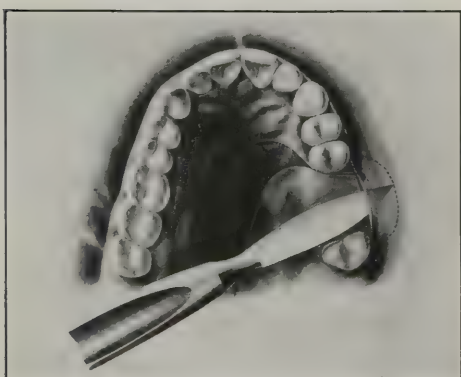

FIG. 77.—Outer edge of palatal flap tucked under labiobuccal flap.

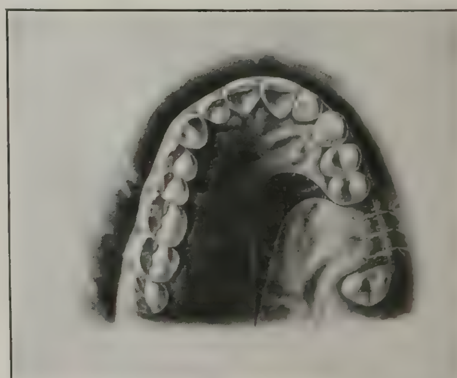

FIG. 78.—Flaps sutured.

cover the opening without tension when sutured in place (Fig. 76.) The labial soft tissues were then very thoroughly undermined and freed, often upward to the extent of an inch or more on the anterior surface of the maxillary bone. The periosteum was not disturbed, and a very nice curtain of soft tissue was dropped to meet and overlap the original flap from the palate; sometimes the anterior border of the labial curtain was freed so that a labial flap was thrown over the palatal one. This was done when the opening into the antrum was

large. The palatal flap was tucked under the foregoing labial curtain (Fig. 77), or sutured over the curtain after the curtain had been sutured in place over the bony opening to be closed. The important point in the disposition of these flaps was to make them overlap each other like a double-breasted coat and to suture them securely. Fairly heavy horsehair sutures were preferred (Fig. 78). External contour in the region of the lips was restored by vulcanite dentures.

The restoration of facial contour following defects due to loss of bone or soft tissues in the region of the cheeks was accomplished by implantation of costal cartilage, abdominal fat and fascia lata beneath the overlying skin. (See Figs. 217–220, p. 482.)

OPERATIVE TREATMENT OF UNUNITED FRACTURES OF THE MANDIBLE WITH LOSS OF SUBSTANCE.[7]

Of 1,123 gunshot fractures of the mandible occurring in the American Expeditionary Forces, there are records that 125, or 11 per cent, resulted in nonunion or in vicious union sufficient to demand bone grafting. The nonunion in these cases was primarily not due to lack of early fixation, but was principally caused by the large loss of bone substance and inability on the part of nature to bridge the gap resulting when the collapsed fragments were drawn apart and fixed in proper position. The loss of bone was not so much the result of total destruction at the time of injury as of extensive shattering followed by infection and necrosis. If the fragments had not received early attention in the form of reduction and fixation, there would have been a much larger proportion of cases of union in bad position, requiring the two separate operations of surgical reduction and bone grafting, instead of grafting alone. There were probably not more than 12 cases of vicious union which required bone grafting on account of nonresponse to radical or slow reduction. Bone grafting in cases of fracture with loss of substance was decided upon only after conservative methods of treatment had been exhausted, and after splinting had been employed for at least six months from date of injury. It was a rule that no operation should be attempted to restore the continuity of a bone until all sources of infection had been removed and until at least six weeks had elapsed after the healing of all sinuses and septic wounds.

Various forms of splints of the same types as those used where spontaneous union was expected were employed to suit individual cases. The object of the splints was to fix the fragments with preservation of the normal occlusal relationship of the remaining lower teeth with the upper. Occasionally, where many sound teeth were present, it was possible to fix the fragments by means of wire ligatures attaching the lower teeth to the upper. (See intermaxillary wiring, Figs. 44–51, pp. 417–419.) Where there were sound teeth in each fragment, it was frequently necessary to splint only the mandibular teeth. (See Figs. 95–97, p. 437.) This had the great advantage of permitting mastication and allowing enough motion to promote bone growth. In other cases, and always where there were no teeth in the posterior fragment, as in fracture at the angle, it was necessary to splint the upper teeth as well as the lower and to lock the two splints in occlusion by means of removable bolts. (See Figs. 4–6, p. 403.) The upward and forward tilting of the ramus of the mandible by the action of the masseter and internal pterygoid muscles in many cases was overcome gradually by means of the vulcanite saddle. (See Figs. 119, 120, p. 443.)

It was found advisable to remove the saddle after reduction had been accomplished and before performing the bone-graft operation because of the irritation produced in the soft tissues and the danger of infecting the graft.

In practically all cases of bone grafting ether anesthesia was used. One of the most convenient methods for work about the face and neck was the introduction of ether vapor into the pharynx through nasal tubes. The usual method of vaporizing the ether was by means of a motor air pump or foot bellows. A very convenient way was to pass oxygen through the ether bottle, thus avoiding the necessity for the air pump. This method permitted the continuous administration of the anesthetic and at the same time the complete isolation of the field of operation by sterile towels covering the head and face without interfering with the anesthetist. In most instances this method of administration of the anesthetic did not interfere with the fixation of the lower teeth to the upper. Where there was any difficulty, the lock pins could be removed from the splints until after the operation.

METHODS OF BONE GRAFTING.

For restoring the lost bone substance, several methods were used, according to the preference of the individual operator and the requirements of the given case. For the majority of cases it mattered little what form of graft was used provided that certain underlying principles were followed, such as waiting until the elimination of all sepsis, the employment of rigid aseptic technique, and the avoidance of infection by opening into buccal cavity. In certain cases, however, there were definite indications for particular types of graft.

PEDICLED GRAFT FROM THE MANDIBLE ITSELF.

This method was first described by Cole.[8] A curved skin incision with convexity downward was made over the bony defect, and extended well into the neck, reaching a lower level in front than behind. A flap consisting of skin only was raised to the requisite level. The posterior fragment was thoroughly exposed. The extremity only of the anterior fragment was exposed, so that the extent of the gap might be gauged. A horizontal incision was then made through the soft parts clothing the outer aspect of the interior fragment at a level immediately below the buccal sulcus. The basal margin of this portion of the jaw was then sawed off through this incision. The periosteum on the inner aspect of the fragment was incised. Lateral incisions through platysma and deep fascia were made to define the pedicle, which was then dissected from the underlying structures. The graft was thus freed to an extent sufficient to allow easy adaptation in its new position. The posterior fragment was next freshened to provide as broad a surface of contact as possible. Anterior and posterior fragments were drilled for the passage of a fine silver wire. The wires were passed through the pedicle, surrounding the graft, and when tightened and twisted they insured snug contact between graft and freshened fragments. Tainter [9] suggested, as giving better fixation, the passing of the wires through holes drilled in the graft itself rather than through the soft-tissue pedicle. The soft parts were brought together with a few catgut sutures and the skin was sutured with or without drainage (Figs. 79a-79g)

FIG. 79 (a).—Incision for Cole's pedicled graft.

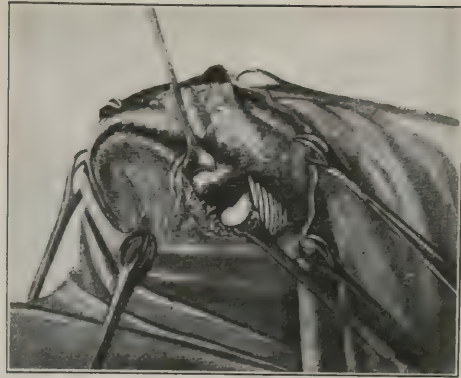

FIG. 79 (b).—Defect in mandible due to loss of bone.

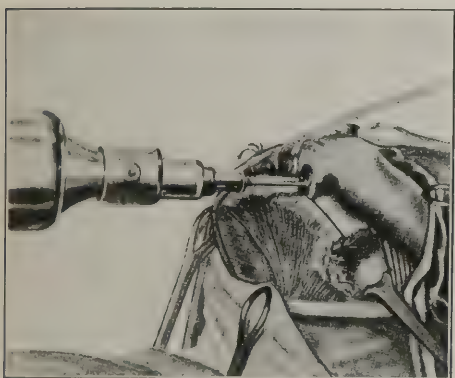

FIG. 79 (c).—Cutting graft from lower border of mandible, leaving its vascular muscular attachment as pedicle.

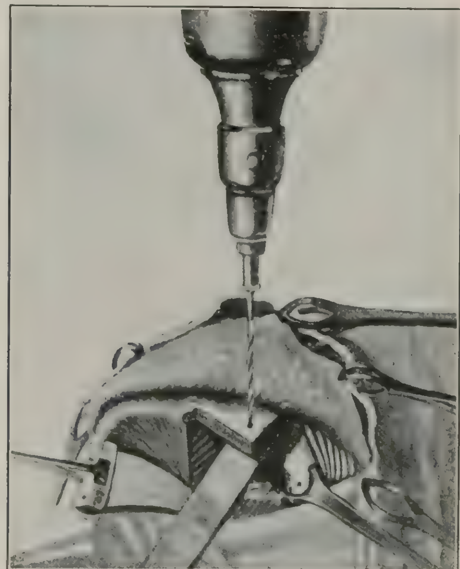

FIG. 79 (d).—Drilling anterior and posterior fragments preparatory to wiring.

FIG. 79 (e).—Wires through fragments and graft.

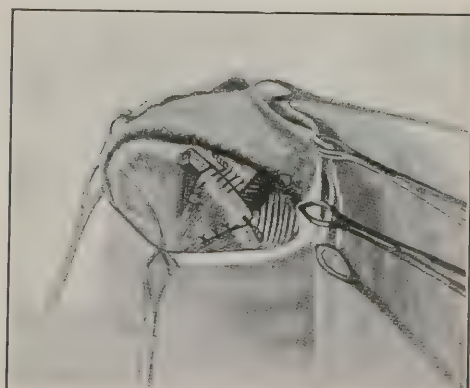

FIG. 79 (f).—Graft in place; wires twisted tight and a few catgut sutures placed to obliterate dead space under pedicle.

Advantages and disadvantages.—The pedicled graft was satisfactory in cases of loss of substance up to 3 cm. in the body or symphysis of the mandible. When used for more considerable loss of substance, the amount of displacement of soft tissues in the pedicle was apt to cause disfigurement and functional disability due to restriction of movements of the tongue and floor of the mouth. This type of graft was not applicable where the ramus was involved. It had the advantages that only one wound was necessary, that there was no danger of complications to other parts of the body, and that it furnished a piece of bone which had not been cut off from its blood supply and which acted not as a mere scaffolding for the rebuilding of new bone to fill in that lost by the injury, but which was from the first an integral part of the mandible. The pedicled graft was not so vulnerable to infection as the free bone graft, and union as a rule took place more rapidly than where a free graft was used.

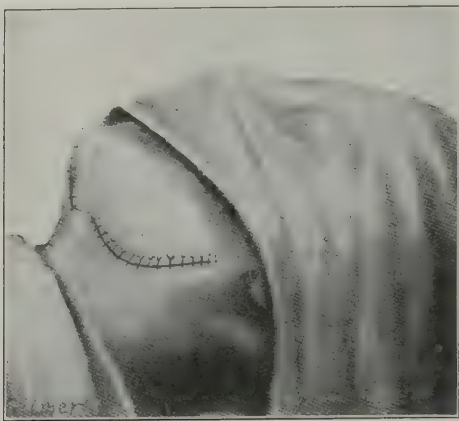

FIG. 79 (g).—Wound closed with fine horsehair.

Results.—Of the first 103 bone graft cases, 31 were grafted by this method, with 27, or 87 per cent, successes. It must be remembered that in securing this large percentage of successes the method was used principally in the most favorable situation for any type of graft, i. e., the body of the mandible with small loss of substance.

The following cases illustrate the use of the pedicle graft from the mandible:

CASE 1.—C. H., Pvt., Co. M, 11th Inf. Wounded October 14, 1918, by machine-gun bullet, which entered right side of face, near junction of ramus and body of mandible, destroying second and third molars and causing comminuted fracture of bone. Bullet was removed and fragments fixed by intermaxillary wiring. Wires were removed from teeth before sailing for United States. Arrived at Walter Reed General Hospital June 17, 1919; no splints; fracture ununited; infection draining from external sinus on face, due to septic lower right first molar tooth. Tooth was extracted and jaws immobilized with intermaxillary wiring of teeth. Figure 80 is from radiograph taken July 9, 1919, showing 1.5 cm. loss of substance, also several small fragments of jacket of bullet embedded in tissue. Two months after healing of sinus, August 26, 1919, a pedicled graft was cut from the anterior stump, carried back, and attached to the two fragments with silver wire. Figure 81 is from a radiograph taken five days after operation, showing graft in place, also intermaxillary wires used for fixation of teeth. Solidification was complete in three months. Figure 82 is a radiograph taken November 17, 1919, showing firm consolidation.

CASE 2.—O. H., Corpl. Co., A, 47th Inf. Wounded September 26, 1918, by machine-gun bullet, causing comminuted fracture of left body of mandible. Treated for three weeks by intermaxillary wiring, and then by an upper and lower cast-metal splint. On admission to Walter Reed General Hospital, March 4, 1919, external wounds were healed, with scar near left angle of mandible. Figure 83 is a photograph taken on admission, showing scar beneath left border of jaw. There was an ununited fracture of the left body of the mandible in the premolar region, with 1 cm. loss of substance. A molar tooth was present in the posterior fragment, and the upper and lower splints were replaced by a cast splint on the mandible alone, permitting the patient to open the mouth. A pedicle graft operation was performed March 26, 1919. Figure 84, a radiograph, shows graft in place one month later. Figure 85 shows firm consolidation three months later. Dentures were inserted and patient was discharged with good function.

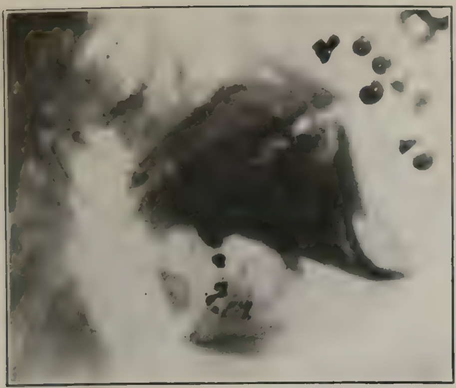

FIG. 80.—Case 1: Pedicled graft from mandible. Radiograph showing loss of substance.

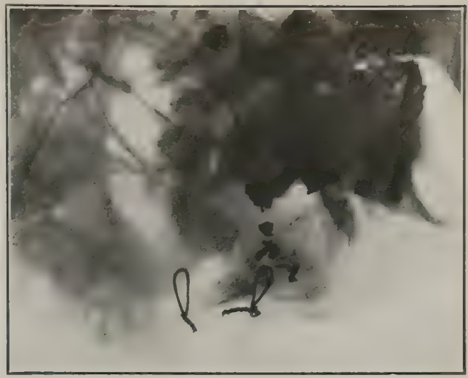

FIG. 81.—Case 1: Radiograph made five days after operation, showing graft in place.

FIG. 82.—Case 1: Radiograph showing firm consolidation, three months after operation.

FIG. 83.—Case 2: Pedicled graft from mandible. Scar beneath left border of jaw.

FIG. 84.—Case 2: Radiograph one month after operation, showing graft in place.

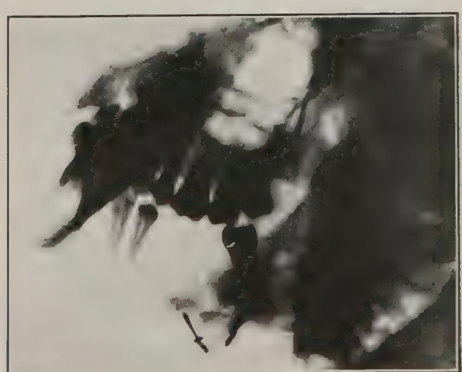

FIG. 85.—Case 2: Radiograph showing firm consolidation, three months after operation.

OSTEOPERIOSTEAL METHOD OF DELAGÉNIÈRE.[10]

A skin incision with convexity downward was made over the region of the injury. The skin flap was turned upward. The deeper tissues were dissected to thoroughly expose the ends of the bone fragments. Extreme care was necessary to avoid opening into the buccal cavity. A pocket was prepared around the end of each fragment by stripping away the periosteum and soft tissues from the bone for a distance of about 1 cm. The ends of the fragments were thoroughly freshened by trimming with rongeur forceps. The antero-internal surface of the tibia was exposed by a longitudinal incision through the skin down to the periosteum. The graft to be removed was next outlined with the knife through the periosteum to the bone. With a broad, thin chisel held perpendicular to the bone the tracing made by the knife was followed, the blade of the chisel penetrating the bone to a depth of 1 to 2 mm. The chisel was then held almost horizontally, and a thin shaving of bone, with overlying periosteum included within the outline traced, was removed. The graft was cut into two or three pieces as desired. One piece was inserted with its ends in the pockets beneath the ends of the mandibular fragments, the bony side of the graft being toward the mandibular fragment. Another piece of graft was inserted in a similar manner over the fragments, with the bony surfaces of the grafts facing each other. It was necessary that the grafts be in contact with the previously freshened bone ends. If desired, a third piece of graft could be placed beneath the fragments. No fixation was used beyond suturing the deep tissues over the grafts and ends of the bone.

Advantages and disadvantages.—The osteoperiosteal method furnished a flexible graft, easily adjustable to the size and shape of the lost bone substance, and containing, theoretically, all the elements necessary for osteogenesis. The technique was simpler than that of other methods. It was suitable for loss of substance of any extent and in any position, whether of body, ramus, or symphysis. It required a longer time to obtain complete consolidation than by other methods, and no dependence could be placed upon the rigidity of the graft itself for fixation. In cases of large loss of substance with visible deformity, this form of graft did not fulfill the immediate cosmetic requirements in as satisfactory manner as some other types.

Results.—In a series of 38 cases operated upon by this method, 27, or 71 per cent, were successful, 3 more being partially successful, and 8 being failures. It should be noted that the osteoperiosteal method was used in some of the most desperate cases, involving large loss of substance of the ramus.

The following are examples of cases treated by the osteoperiosteal method:

CASE 3.—O. K., Pvt., Co. F, 127th Inf. Wounded October 4, 1918, by high-explosive fragment, which struck left side of body of mandible, causing comminuted fracture in region of left angle and ramus. Fragments were fixed in France by intermaxillary wiring and later by swaged-metal cap splints for upper and lower teeth, the two parts being connected by ligature wire attached to hooks (Figs. 86 and 87a). Admitted to Walter Reed General Hospital in January, 1919. Wound healed except for discharging sinus over site of fracture. Nonunion, with 3 cm. loss of substance of left angle and ramus. Figure 88 shows region of injury shortly after admission to Walter Reed General Hospital. Figure 89 is a radiograph showing loss of substance, with posterior root of first molar projecting into area of fracture. This tooth was extracted, and the jaws were fixed in occlusion by means of cast silver cap sprints for upper and lower arches fastened with lock pins (Fig. 87b). Osteoperiosteal graft operation performed April 25, 1919. Figure 90 is a radiograph made May 3, 1919, one week after operation, showing internal, external, and inferior osteoperiosteal

strips from tibia inserted between fragments. Figure 91 is a radiograph made June 4, 1919, showing proliferation of new bone from ends of fragments along osteoperiosteal strips. Lock-pins were removed from splints September 9, 1919, to permit mastication. Consolidation practically complete. Figure 92 is a radiograph made the same day, showing dense deposit of new bone between the two fragments.

FIG. 86.—Case 3: Swaged-metal cap splints for upper and lower teeth, connected by ligature wires attached to hooks.

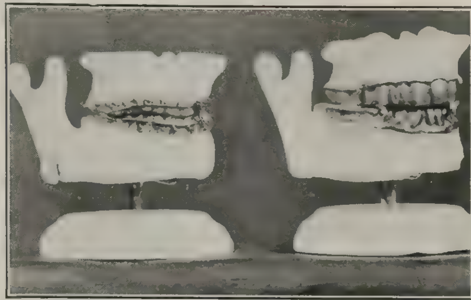

FIG. 87.—Case 3: (a) Splints in place. (b) Cast-silver cap splints for upper and lower arches fastened with lock-pins.

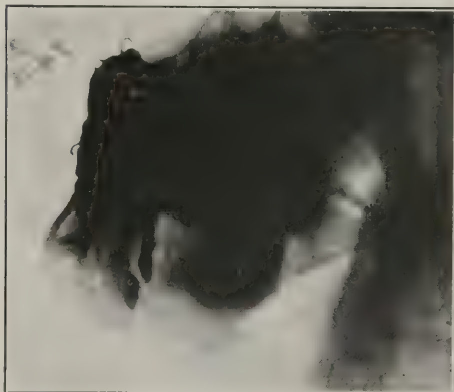

FIG. 89.—Case 3: Radiograph showing loss of substance, posterior root of first molar projecting into area of fracture.

FIG. 88.—Case 3: Osteoperiosteal graft. Region of injury about three months before operation.

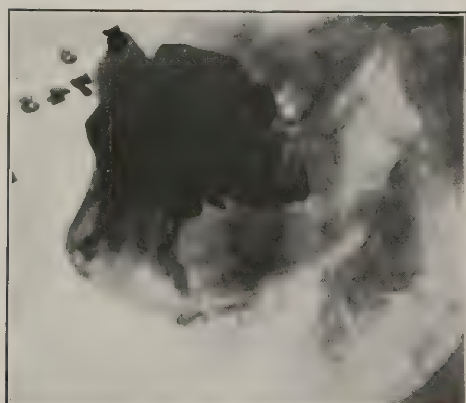

FIG. 90.—Case 3: Radiograph made one week after operation, showing three osteoperiosteal strips from tibia inserted between fragments.

FIG. 91.—Case 3: Radiograph made six weeks after operation, showing proliferation of new bone.

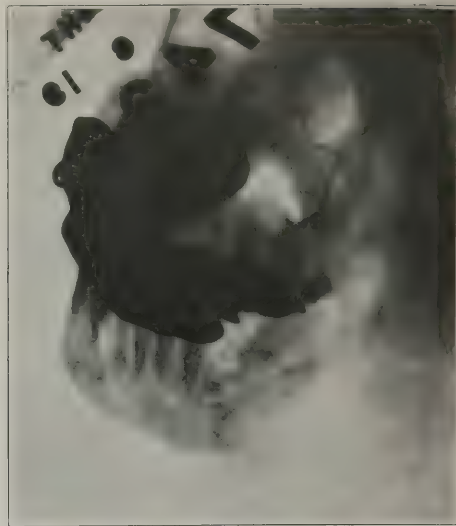

FIG. 92.—Case 3: Radiograph made about five months after operation, showing practically complete consolidation.

CASE 4.—M. M. Wounded September 29, 1918, by high-explosive fragment which struck right side of body of mandible, producing comminuted fracture. In France the fragments were held in position by intermaxillary wiring. Arrived at Walter Reed General Hospital February 19, 1919, presenting opening in right cheek discharging pus from necrotic bone (Fig. 93). Ununited fracture of right body of mandible with about 2 cm. loss of substance and sequestra (Fig. 94). From the radiograph it may be noted that the lower right third molar was in excellent condition, vital and well invested by alveolar process, thus making it invaluable for retention. Figure 95 shows simple inferior dental cast-silver splint, and Figure 96 buccal aspect of right side of splint. An angle fracture band was attached to the remaining molar in the posterior fragment, with traction screw and lock nut designed to force the ramus downward and backward, rotating it on the head of the condyle so as to restore the radius between the right condyle and symphysis to the same length as that of the left side. Figure 97 shows the buccal aspect of left segment of splint, showing cast Gilmer flange designed to glide over the buccal surfaces of the upper posterior teeth in order to preserve the natural occlusion without the need of locking the mandible to the upper jaw. Sequestrectomy was performed February 21, 1919; sinus healed February 28, 1919. Osteoperiosteal graft operation May 12, 1919, two strips from tibia being placed between fragments. Figure 98 is a radiograph taken July 14, 1919, two months after operation; outline of grafts are evident. Figure 99 is a radiograph, October 31, 1919, demonstrating a rapid and satisfactory growth of bone in progress. Figure 100 is a radiograph, January 7, 1920, showing dense deposit of bone between the stumps. Splint removed and solid union demonstrated. Lost teeth replaced by denture.

FIG. 93.—Case 4: Osteoperiosteal graft. Photograph February, 1919, showing opening in right cheek discharging pus from necrotic bone.

Fig. 94.—Case 4: Radiograph showing ununited fracture of right body of mandible with loss of substance and sequestra.

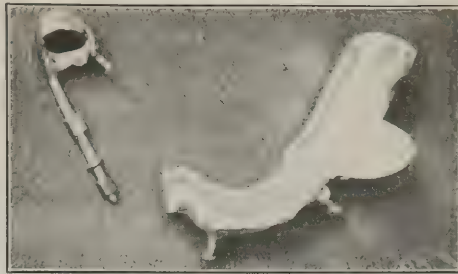

Fig. 95.—Case 4: Inferior dental cast-silver splint.

Fig. 96.—Case 4: Buccal aspect of right side of splint.

Fig. 97.—Case 4: Buccal aspect of left side of splint, showing Gilmer flange.

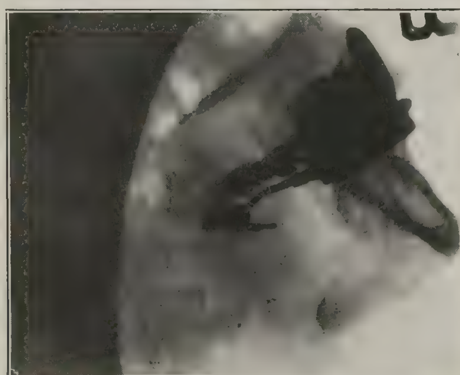

Fig. 98.—Case 4: Radiograph taken two months after operation, showing outlines of grafts.

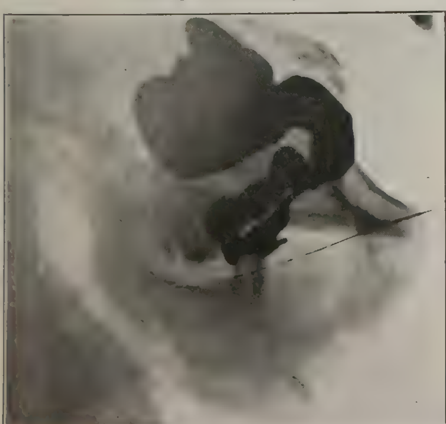

Fig. 99.—Case 4: Radiograph five months after operation, showing growth of bone.

Fig. 100.—Case 4: Radiograph eight months after operation, showing consolidation.

CASE 5.—W. O. S., Sgt., 320th Inf. Wounded September 28, 1918. Machine-gun bullet entered right cheek, passing transversely through face, taking a downward and backward course, penetrated left side of mandible at junction of ramus and body, and made exit through overlying structures of left cheek. Comminuted fracture of left angle and ramus of mandible. Profuse

FIG. 101.—Case 5: Osteoperiosteal graft. External appearance showing healed scar of wound of exit.

FIG. 102.—Case 5: Radiograph showing large loss of substance of ramus and displacement of upper segment.

FIG. 103.—Case 5: Radiograph, one month after operation, showing grafts in good contact with both stumps of mandible.

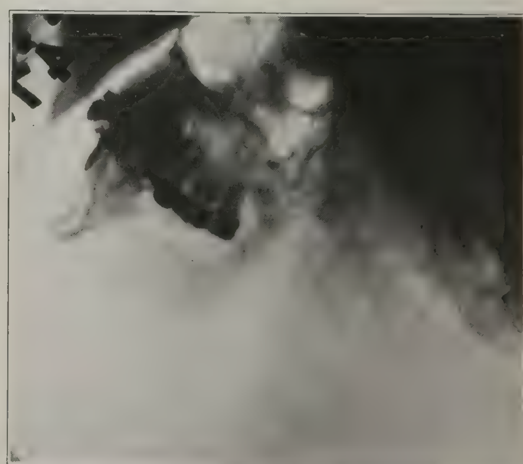

FIG. 104.—Case 5: Radiograph five months after operation, showing solidification.

secondary hemorrhage two weeks after injury, requiring ligation of left external carotid artery. Admitted to Walter Reed General Hospital April 1, 1919. No infection; wounds healed. Figure 101 shows healed scar at point of exit. There was an ununited fracture of left angle and ramus of mandible with $2\frac{1}{2}$ cm. loss of substance. Figure 102 is from a radiograph taken April 10, 1919,

showing the lower three-fifths of the ramus entirely missing, with the upper segment pulled high into the zygomatic fossa, in such a position as to render an intraoral control impossible. Illustration also shows swaged German silver cap splints made overseas. These splints were removed and replaced by intermaxillary wires on teeth. July 14, 1919, an osteoperiosteal graft operation was performed, the wound being closed without drainage. Figure 103 is a radiograph taken August 3, 1919, showing outline of grafts in good contact with both stumps of mandible. Figure 104 is a radiograph made December 20, 1919, showing mandible solidified by fusion of newly developed bone. January 20, 1920, intermaxillary wiring removed, and union complete. Dentures made and patient discharged with good function.

FREE GRAFT FROM CORTEX OF TIBIA.

The ends of the mandibular fragments were exposed and prepared in a manner similar to that described for the osteoperiosteal method, with the addition that the ends were drilled with holes for the passage of silver wire or kangaroo tendon used for fixation of the graft. In removing the graft from the cortex of the tibia the technique of Albee was generally followed, a piece of sufficient size to bridge the gap being removed. With the lower jaw it was difficult in most cases to obtain sufficient exposure to prepare the fragments and the graft for the perfect inlay attained by Albee in the long bones. Nor was this necessary, as we depended largely for fixation on interdental splints. Broad contact was necessary, however, between the tibial graft and the freshened mandibular fragments.

Advantages and disadvantages.—With moderate loss of bone substance where entire dependence could not be placed on interdental splints for fixation, the cortical tibial graft had its greatest field of usefulness. The extreme density of the bone and its consequent resistance to penetration of new blood vessel in the process of consolidation, rendered it less suitable in most cases than bone taken from other sources.

Results.—Of a total of 17 cases, 12, or 70.6 per cent, were entirely successful and 1 was partially successful.

In the following cases a cortical graft from the tibia was used:

Case 6.—H. S., Pvt., Co. A, 126th Inf. Wounded October 15, 1918, by machine-gun bullet, which entered chin about one-half inch below the left corner of mouth and, taking a downward and backward course, made its exit through the body of the mandible on the right side, causing extensive loss of substance. During the following two months a continuous irrigation treatment was used and quantities of bone fragments were removed from time to time. No splints were used, but an attempt was made to retain the lower left posterior teeth in occlusion by intermaxillary wiring. Patient arrived at Walter Reed General Hospital January 27, 1919, with ununited fracture and large loss of substance of right body of mandible, no infection, no splints. Figure 105 shows external appearance on admission, and Figure 106, destruction of left half of lower lip. The patient dribbled saliva constantly. Figure 107 is a radiograph showing loss of substance in right body of mandible and collapse of symphysis. In Figure 108 is seen apparatus with Jackson spring clasp attachment to remaining lower teeth made as a support for lower lip after plastic operation. Several plastic operations were performed on the lip and on August 13, 1919, a pedicled bone-graft operation was performed, which partly closed the gap, but united only at the anterior end. Figure 109 is a radiograph after reduction of fragments by insertion of splints, before bone-graft operation. The symphysis was brought out to approximately normal position, while pressure of vulcanite saddle forced ramus backward. On October 22, 1919, a cortical graft from right tibia was inserted and proved successful. Figure 110 is a radiograph showing tibial graft in position. August 17, 1920, a complete solidification of the graft was demonstrated by the radiograph shown in Figure 111. Figure 112 shows external appearance after insertion of graft and repair of lip.

FIG. 105.—Case 6: Graft from cortex of tibia. External appearance of patient before operation.

FIG. 106.—Case 6: Showing destruction of left half of lower lip.

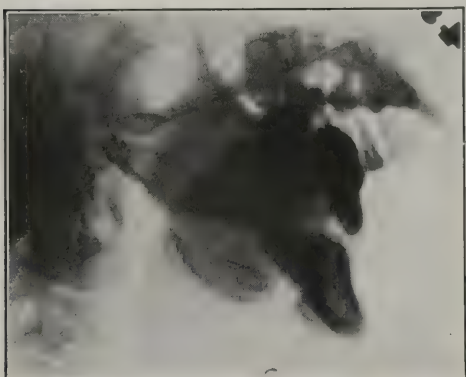

FIG. 107.—Case 6: Radiograph showing loss of substance in right body of mandible and collapse of symphysis.

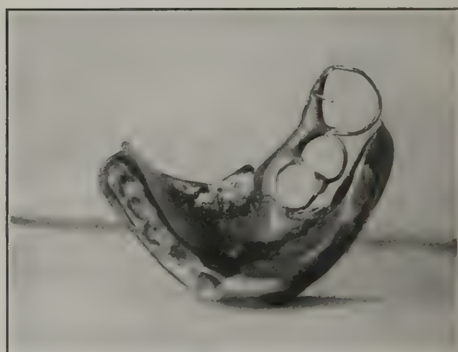

FIG. 108.—Case 6: Apparatus with Jackson spring-clasp attachmena made as a support after plastic operation on lower lip.

FIG. 109.—Case 6: Radiograph made after reduction of fragments and insertion of splints, before bone-graft operation.

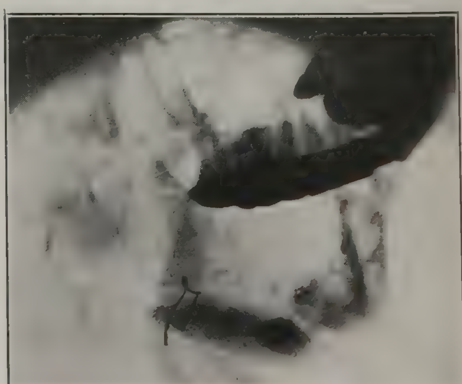

FIG. 110.—Case 6: Radiograph showing tibial graft in position.

CASE 7.—A. R., Pvt. Co. D, 117th Inf. Wounded September 29, 1918, by high-explosive fragments striking squarely against right body of mandible. Early treatment consisted of the usual routine of removal of bone fragments, irrigation, etc., the only fixation consisting of intermaxillary wires on teeth, which were worn until January, 1919. Figure 113 was made about ten days after injury. An early plastic repair was done, as shown in Figure 114. Figure 115 shows condition after healing from this operation. On arrival at Walter Reed General Hospital, March 2, 1919, there was nonunion, with large loss of substance of right body of mandible, and a small external sinus draining from seat of fracture. Figure 116 shows external appearance at that time, and Figure 117 the collapse of the mandibular fragments, that on the left side being drawn over toward the right. Appearance after operations were completed is shown in Figure 118. The external sinus closed after treatment for a few days. Cast-silver splints with lock pin and vulcanite saddle

FIG. 111.—Case 6: Radiograph ten months after operation, showing consolidation.

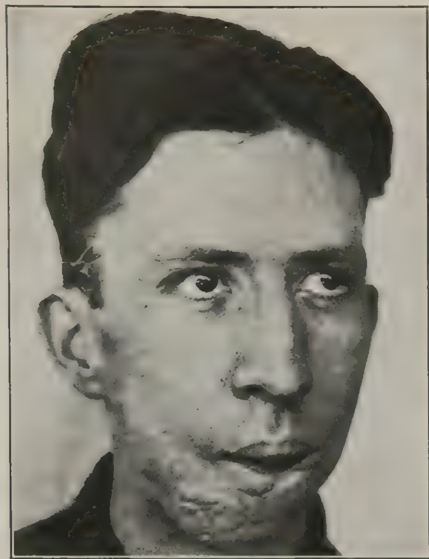

FIG. 112.—Case 6: External appearance after insertion of graft and repair of lip.

FIG. 113.—Case 7: Graft from cortex of tibia. Photograph made about ten days after injury.

FIG. 114.—Case 7: Photograph made after early plastic repair.

for ramus, shown in Figures 119 and 120, were inserted, and a bone graft operation was attempted on July 7, 1919, but in exposing the bone ends the buccal cavity was accidentally opened and operation was discontinued. August 25, 1919, a graft from crest of ilium was inserted, but was lost from suppuration. Figure 121 is from a radiograph made in February, 1920, showing about 4

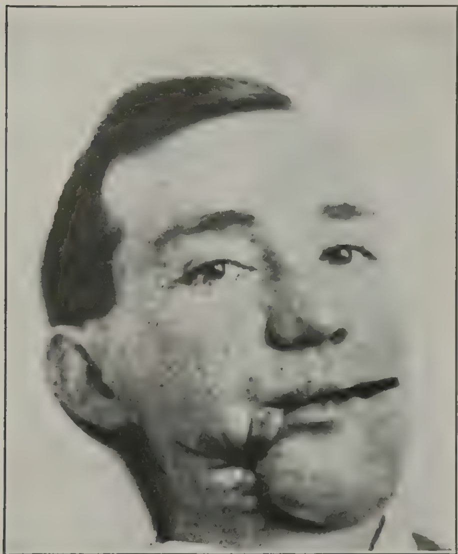

FIG. 115.—Case 7: Condition on healing from early operation.

FIG. 116.—Case 7: External appearance five months after injury.

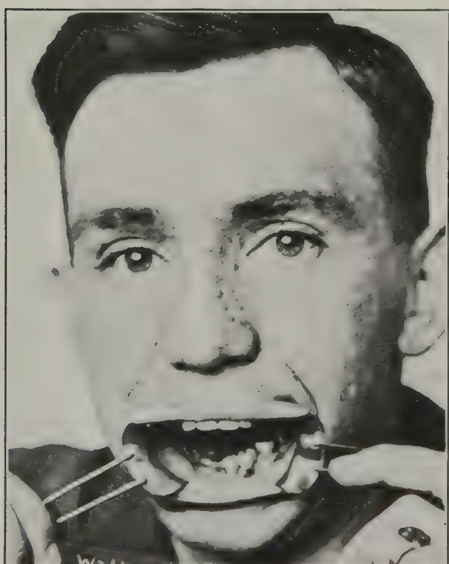

FIG. 117.—Case 7: Showing collapse of mandibular fragments due to nonunion and loss of substance.

FIG. 118.—Case 7: Shows final external appearance after various operations.

cm. loss of substance in right body and angle of mandible. In March, 1920, a thick cortical graft from right tibia was placed between the fragments, and fastened with silver wire. Figure 122 shows tibial graft in place. Six months later, splints were removed, graft was found to have solidified, and dentures were inserted.

FREE GRAFT FROM CREST OF ILIUM.

The ends of the mandibular fragments were exposed and prepared in the usual way, holes being drilled near the ends for the passage of the fixation wires or sutures. An incision was made through the skin over the crest of the ilium, beginning at the anterior superior spine and extending back as far as desired along the top of the ridge down to the bone. The muscles arising from the

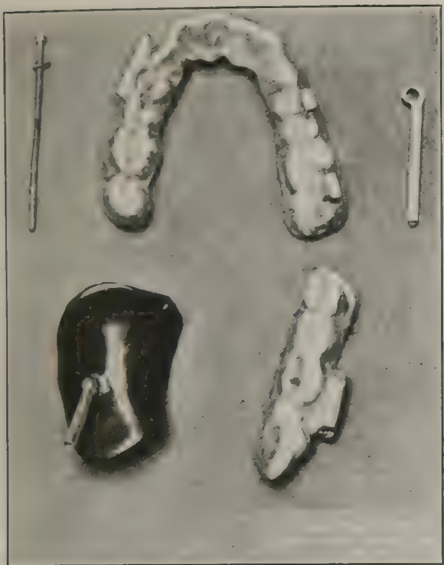

FIG. 119.—Case 7: Cast-silver splint with lock-pin and saddle for ramus.

FIG. 120.—Case 7: Splint assembled.

FIG. 121.—Case 7: Radiograph showing loss of substance in right body and ramus of mandible.

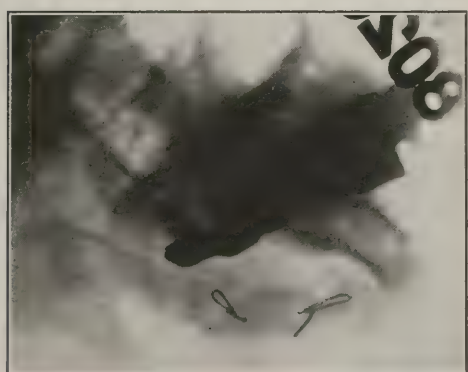

FIG. 122.—Case 7: Radiograph showing tibial graft in place.

inner and outer lips of the incision were detached with the knife and the periosteal elevator. With a metacarpal saw or an electrically driven circular saw, beginning at and including the anterior superior spine, a piece of the entire width of the crest was removed, the required length being determined by measuring the mandibular gap. The graft, handled only with forceps, was drilled at each end, placed between the mandibular fragments, and fixed to them by

means of silver wires or kangaroo tendon. The deep tissues and skin were sutured over the graft in separate layers. If necessary to carry away any oozing blood, a rubber drain was inserted under the skin and left in situ for 24 hours. Whatever the type of operation, it was of the greatest importance, in order to avoid infection, that hemostasis be secured before inserting the graft. In all methods of free bone grafting the exposure and preparation of the fragments was done first, for two reasons: (1) In case of accidental opening into the buccal cavity, the operation was immediately discontinued, and the graft would not have been needlessly removed; (2) no time was lost and there was no consequent risk of contamination between removal of the graft and its insertion in the jaw defect.

Fig. 123.—Case 8: Graft from crest of ilium. Radiograph showing loss of substance and upward displacement of posterior fragment.

Advantages and disadvantages.—The use of a graft from the crest of the ilium was the method of choice of Gillies and his coworkers at Queens Hospital, Sidcup, England.[11] It furnished a large, thick piece of bone, of porous structure closely allied to that of the mandible and easily penetrated by new vascular supply. It could be used for losses of substance of almost any size, and could be readily cut to suitable shape. Crest of ilium was especially adapted to cases in which considerable rigidity was desired, also for an immediate cosmetic result where the loss of substance had produced much visible deformity. The disability produced by removal of the graft was quite temporary, and the danger negligible.

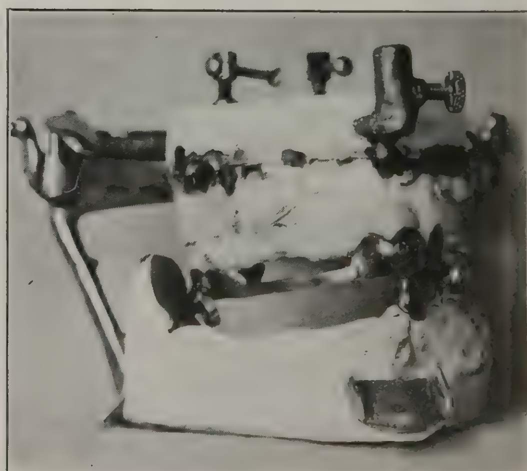

Fig. 124.—Case 8: Upper and lower cast-silver splints with lock-pin and saddle for holding down posterior fragment.

Results.—In our series only seven cases were operated upon by this method. Of these, five, or 71 per cent, were entirely successful; one was partially successful, with union at one end; and one was lost from suppuration. The series is too small to form a basis for comparison with other methods. A graft from the crest of the ilium was used in the following cases:

Case 8.—J. B., Pvt., Co. F, 109th Inf. Wounded July 15, 1918, by shell fragment, causing multiple wounds of face and comminuted fracture of right side of mandible. Returned to United

States with ununited fracture of right body of mandible, with 5 cm. loss of substance. A rib graft was inserted at General Hospital No. 11, November 25, 1918, but this was lost from suppuration. Transferred to Walter Reed General Hospital May 28, 1919; all wounds healed, nonunion of fracture, with considerable swelling of tissues over site of fracture, probably due to lymphatic obstruction. Figure 123 is a radiograph made June 7, 1919, showing loss of substance and upward displacement of posterior fragment by elevator muscles. Figure 124 shows immobilizing apparatus consisting of upper and lower cast-silver splints connected by lock-pin. A saddle lined with velum rubber was made to engage the posterior fragment, holding the latter down in position. August 18, 1919, graft from crest of ilium. Figure 125 is a radiograph made about one month after operation, showing graft in position. Firm union in six months.

FIG. 125.—Case 8: Radiograph made one month after operation, showing graft in position.

CASE 9.—G. C., Pvt.; Co. B, 141st Inf. Wounded October 8, 1918, by machine-gun bullet, causing extensive wound of chin and comminuted fracture of right body of mandible. October 9, 1918, wound sutured and fracture fixed by wiring lower teeth to upper. January 25, 1919, wires removed and splints applied. Admitted to General Hospital No. 11, Cape May, N. J., about March 31, 1919. May 15, 1919, plastic operation performed on lower lip. This consisted in turning flap from right nasolabial fold and placing it in labiomental region of chin to raise lower lip. Figure 126 shows condition after healing from this operation. Some contraction occurred, producing an open space between upper and lower lips when in a state of rest. Transferred to Walter Reed General Hospital, June 27, 1919; wound healed; nonunion of fracture of right body of mandible, triangular piece of bone having been lost. Figure 127 is a radiograph taken July 9, 1919, showing loss of all compact portion of bone between left lateral incisor and right first molar. Figure 128 shows cast-silver upper and lower splints which were then made. The lower splint was first inserted and the arch expanded to its normal width by means of the jackscrew, after which the upper splint was put on and the lower fastened to it by means of the lock pins. September 5, 1919, the triangular loss of bone was supplied by a graft from the crest of the ilium. Figure 129 is from a radiograph taken about a month after the operation, showing graft in place, filling out the natural contour of the mandible. November 10, 1919, a V—Y operation was performed to raise the lower lip. Figure 130 shows the condition shortly after this operation. February 20, 1920, the splints were removed and lost teeth supplied by denture. Union and function good. Figure 131 shows completed case after insertion of denture.

FIG. 126.—Case 9: External appearance after plastic operation on lip.

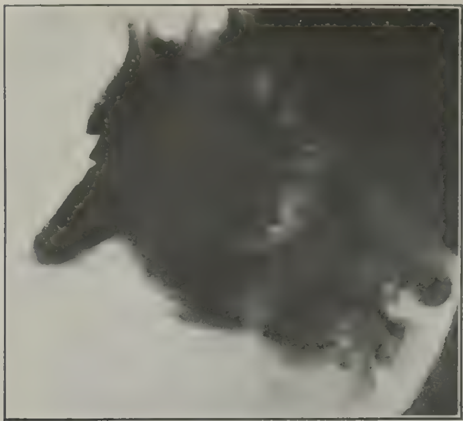

Fig. 127.—Case 9: Radiograph showing loss of all compact bone between left lateral incisor and right first molar.

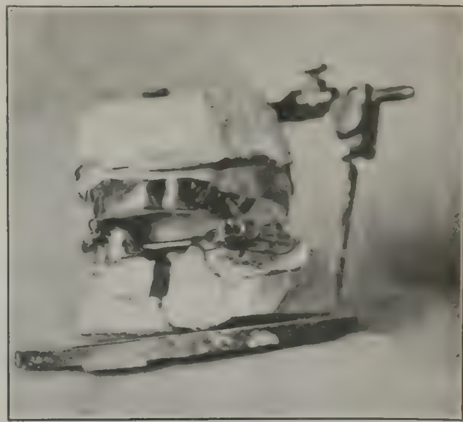

Fig. 128.—Case 9: Cast upper and lower splints with jackscrew expanding device for lower arch.

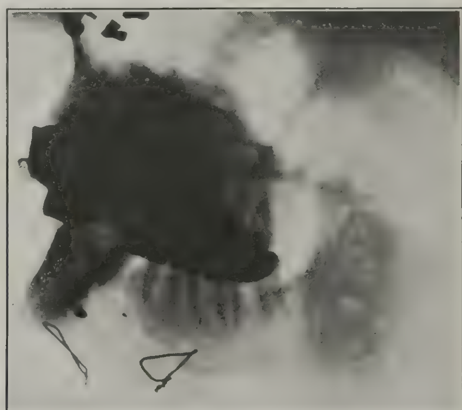

Fig. 129.—Case 9: Radiograph taken one month after operation, showing bone graft in place.

Fig. 130.—Case 9: Lower lip raised by V-Y operation.

Fig. 131.—Case 9: Completed case after insertion of dentures.

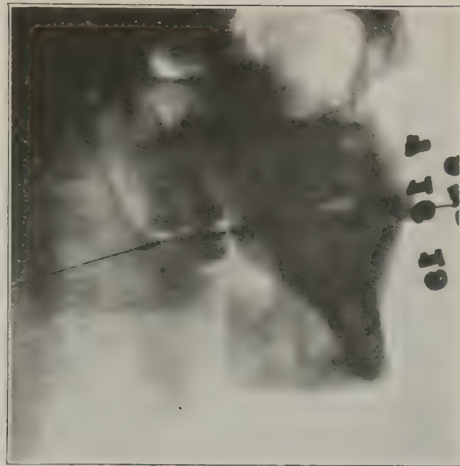

Fig. 132.—Case 10: Graft from crest of ilium, Case 3. Radiograph showing loss of triangular piece of mandible.

Fig. 133.—Case 10: Cast-silver splint with Angle band and traction screw.

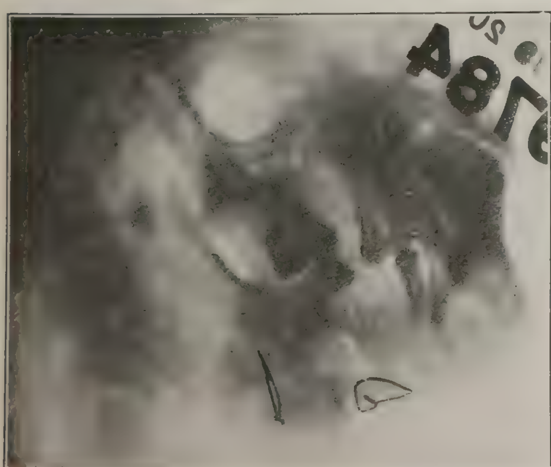

Fig. 134.—Case 10: Radiograph five months after operation, showing union taking place.

CASE 10.—A. T., Sgt., Co. C, 165th Inf. Wounded July 29, 1918, by rifle bullet, which entered beneath chin and emerged about the middle of the right side of the lower jaw, producing a comminuted fracture. In France the fracture was treated by intermaxillary wiring. Admitted to Walter Reed General Hospital, July 14, 1919, with ununited fracture of right body of mandible between insertion of digastric and masseter; no infection present. Figure 132, radiograph taken July 16, 1919, shows loss of triangular piece of mandible, involving a large portion of the compact bone below and becoming narrower toward the alveolar process. The cast-silver encapping splint with Angle band and traction screw, shown in Figure 133, was adjusted to control fragments. Graft from crest of ilium was inserted September 12, 1919. Figure 134 is from radiograph made February 19, 1920, showing iliac graft firmly fused to fragments. Splint removed, union complete. Figure 135, made three months later, shows still further radiographic consolidation.

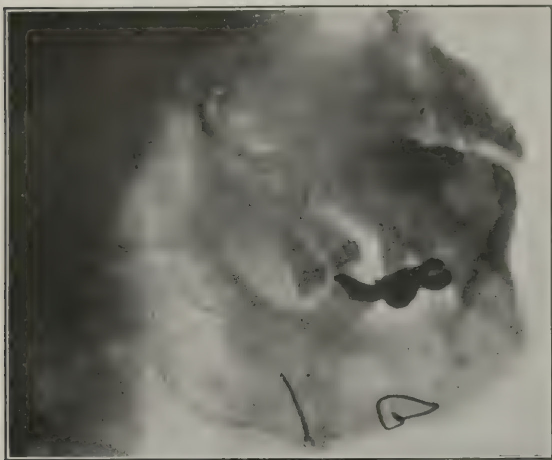

FIG. 135.—Case 10: Radiograph eight months after operation, showing still further consolidation.

FREE RIB GRAFT.

In using this method a piece of rib, generally the seventh, was resected in the usual way, with or without periosteum attached, care being taken not to open the pleural cavity. This was trimmed to proper length and inserted between and in contact with the previously prepared mandibular fragments, being fastened to them with silver wire or kangaroo tendon. A green stick fracture could be made in the piece of rib to simulate an angle or curvature of the jaw.

Advantages and disadvantages.—The rib is porous and easily penetrated by new vascular supply. It could be readily made to conform to the natural contours of the jaw, and large gaps could be spanned. On the other hand it made a rather thin and weak graft for large losses of substance. The dangers incident to opening the chest cavity should not be ignored.

Results.—Six cases of the series were operated upon by this method, all being successful. The following cases exemplify the use of the rib graft:

CASE 11.—H. L. B., Pvt., Co. H, 305th Inf. Wounded August 16, 1918, by high-explosive fragment, which entered left side of face in the region of the upper posterior teeth, passed through the tongue, and, taking a downward course, made its exit through the body of the mandible on the right side. There was extensive destruction of the upper left teeth and alveolar process, the left maxillary sinus was invaded, the tongue was badly lacerated, and there was extensive loss of substance of the body of the mandible on the right side. The patient suffered from severe infection and secondary hemorrhage about three weeks after receipt of wound. He arrived at General Hospital No. 11, Camp May, N. J., in December, 1918, presenting nonunion and extensive loss of substance of right body of mandible. Figure 136 shows the external appearance. The fragments were fixed to the upper jaw by means of cast-aluminum splints fastened together with lock screws. In April, 1919, a section about 2½ inches long was excised from the right sixth rib and planted in position between the jaw fragments, overlapping the fragments at each end, and secured with silver wire. Figure 137 shows details of operation. Figure 138 is from a radiograph showing graft in place. Figure 139 is from a radiograph taken July 15, 1919. In August, 1919, the splints were removed; consolidation was complete; dentures were inserted.

CASE 12.—G. C., Pvt., Co. C, 316th Signal Corps. Wounded September 28, 1918, by high-explosive fragment, which struck the left side of body of mandible, passed through the face, and made its exit through the opposite side, destroying all of the bone of the mandible from the left second molar to the right first premolar. All of the overlying soft tissues of the chin and lower lip

FIG. 136.—Case 11: Rib graft. External appearance before operation.

FIG. 137.—Case 11: Diagram showing details of rib-graft operation.

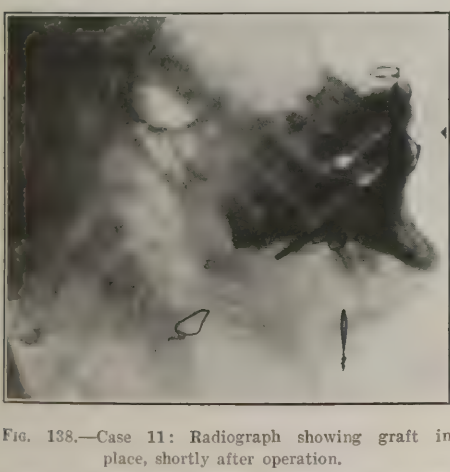

FIG. 138.—Case 11: Radiograph showing graft in place, shortly after operation.

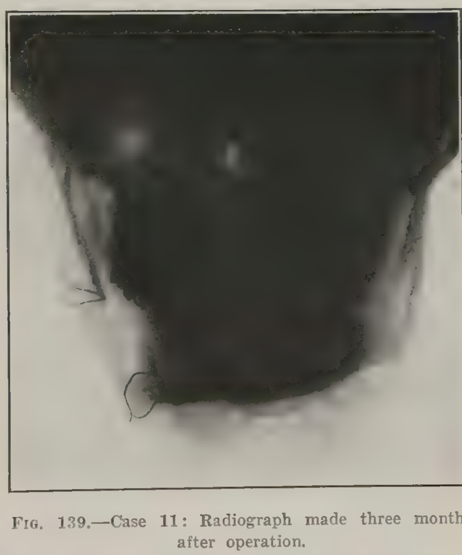

FIG. 139.—Case 11: Radiograph made three months after operation.

were torn into large flaps. Treatment overseas consisted in caring for sepsis, removal of sequestra, gradual drawing together of soft tissues and temporary fixation of jaw fragments by intermaxillary wiring of teeth. In February, 1919, arrived at General Hospital No. 11, Cape May, N. J. Figure 140 shows appearance shortly after arrival from overseas, with extensive deformity of chin and

lower lip. Figure 141 shows temporary chin appliance made of vulcanite, used to improve appearance and control saliva. Metal caps were made for the remaining upper and lower teeth, and these were fastened in occlusion by ligature wires. A large loss of bony substance of the mandible was replaced by a graft from the sixth rib. Transferred to Walter Reed General Hospital June 16, 1919. The radiograph (Figs. 142 and 143) show the graft in position, and absorption of bone about all of the teeth, due to infection. These teeth were retained at the time of operation, being the

FIG. 140.—Case 12: Rib graft. Appearance shortly after return from overseas, with extensive deformity of chin and lower lip.

FIG. 141.—Case 12: Temporary chin appliance made of vulcanite.

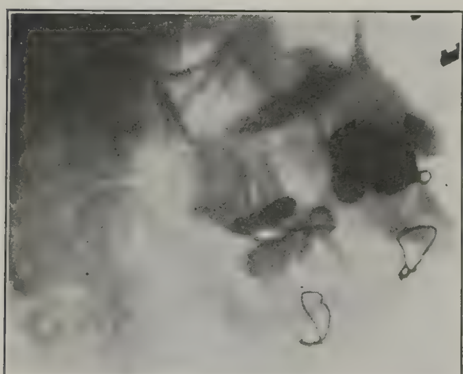

FIG. 142.—Case 12: Radiograph showing rib graft in position, and bone absorption about teeth, due to infection.

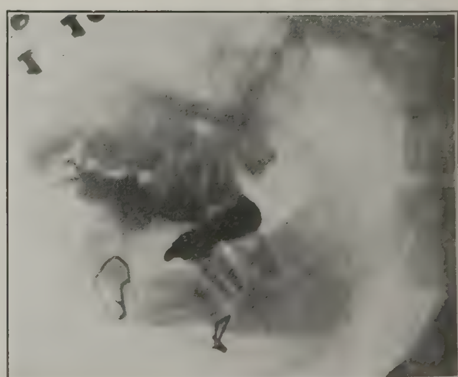

FIG. 143.—Case 12: Radiograph of other side showing similar condition.

only means for retention of the fragments. There was a sinus discharging pus on the left side below the border of the jaw. This healed immediately after removal of septic teeth. Consolidation of bone eventually occurred, as shown in Figure 144. Figure 145 shows appearance of patient after infected sinus had healed. Several supplementary plastic operations were performed on lower lip and buccal sulcus, and artificial dentures were inserted. Figure 146 shows denture in position, and Figure 147 the final result.

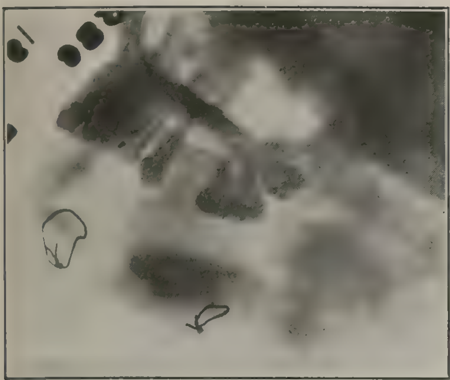

FIG. 144.—Case 12: Radiograph showing consolidation.

FIG. 145.—Case 12: External appearance after healing of sinus.

FIG. 146.—Case 12: Denture in position.

FIG. 147.—Case 12: Final appearance after several supplementary plastic operations.

RAMUS SLIDING GRAFT.

In fractures in the region of the posterior part of the body and angle of the mandible with large loss of substance it was occasionally deemed advisable to make a horizontal section through the ramus and to slide the lower portion forward to bridge the defect. Of three cases treated in this way two were successful and in one union failed to occur

HETEROGENEOUS GRAFTS.

One case came under observation in which a large loss of substance of the body of the mandible had been replaced by a piece of beef bone. No union had occurred and extensive absorption of the graft was taking place. The experience of all observers strongly supports the belief that only autogenous grafts should be used.

SUMMARY OF RESULTS OF BONE-GRAFTING OPERATIONS.

Of the series of 103 graft operations, 78, or 75 per cent, are recorded as entirely successful. Partial success was attained in eight, or 7.7 per cent. By partial success is meant union at one end only. In most of these cases a second supplementary operation was necessary to establish complete union. In many of these cases, and also in some in which failures are reported, a second or even a third operation eventually resulted in success.

POSTOPERATIVE TREATMENT IN BONE GRAFTING.

The splints were kept in place for from three to six months after the graft operation, this depending upon the extent and the situation of the loss of substance. Other things being equal, bone regeneration occurred more rapidly in the body of the bone than in the ramus. After a month of complete fixation the splints were unlocked at intervals to permit gentle exercise of the jaw and to stimulate bone growth. It was surprising to note a persistent springiness at the site of the graft stiffen up in a week after allowing slight motion. Follow-up radiographic examinations were made once a month. After removal of the splints upon completion of consolidation, the lost teeth were replaced by artificial dentures. In some cases it was necessary at first to insert temporary pieces, later replaced by those of a more permanent character as the hard and soft tissues conformed to the new conditions.

TRISMUS AND ANKYLOSIS.

A not uncommon complication of maxillofacial injury or disease, and one which sometimes demanded great ingenuity and attention to detail for its correction, was limitation of the motions of the mandible, with resultant inability to separate the upper and lower teeth to varying degrees. To this condition it was the custom during the war to apply the term "trismus," no matter what the cause or the extent of the disability. Strictly speaking, this term should be applied only to cases of limitation that are due to muscular contracture or spasm, whether dependent upon nerve irritation, inflammation, or foreign bodies; for all other cases the term "ankylosis" should be used. Ankylosis, again, is subdivided into extra-articular or false, and articular or true, according to whether the limitation is due to involvement of structures

outside the mandibular joint or within the joint itself. True ankylosis as a result of gunshot injury was rare, and in cases of limited movement of the mandible one usually had to deal with some lesion of the extra-articular structures, such as fibrous adhesions within the mouth following destruction of the mucous membrane, bands of scar tissue in the cheeks, foreign bodies embedded in muscles, inflammatory infiltration due to sepsis or aberrant callous formation due to malunion of fractures. The important points preliminary to treatment were the determination of the cause of the limitation of motion and its exact location. Not infrequently the patient would endeavor to make it appear that the condition was worse than it really was. In patients with partial opening the maximum degree of possible motion of the mandible could be tested by inserting a tongue depressor into the mouth and, by stroking the pillars of the fauces with a long applicator covered with cotton, so as to produce gagging, then by passing the tongue depressor downward against the lower teeth the patient could be made involuntarily to open the mouth several millimeters wider than seemed possible by voluntary effort. In cases of complete limitation of motion in which there was any doubt as to its genuineness general anesthesia was frequently employed. Visual and digital examination usually revealed the presence and location of limiting scar bands within the mouth or substance of the cheek. A radiographic examination was made in all cases for the location of septic teeth, to demonstrate the presence of any foreign bodies, to detect ossification in muscular or other soft tissues, and to diagnose displaced fragments of bone in comminuted fractures. The amount of resistance encountered in attempt to separate the jaws was next tested by means of a wedge or mouth gag inserted between the teeth. This resistance was in some cases slight and easily overcome by the wedge or gag, in others it was impossible to produce any separation at all by these means.

TREATMENT.

In the less severe cases, due to the presence of slight adhesion or muscular infiltration, where no obvious cause was found, the resort to gradual wedging usually met with success. Numerous forms of mechanical apparatus were successfully employed for stretching and their selection necessarily depended upon the extent to which the mouth could be opened in the beginning of treatment, the number of teeth present in the upper and lower dental arches and the amount of stress which the patient was capable of standing. It was regarded as a good principle to begin very gradually in order to school the tissues to the point of enduring an effective amount of force without inviting irritation (Fig. 148). If the original efforts were too drastic, the irritation caused was liable to lead to further pathological changes with a consequent back-set or with further complications. In the beginning the common spring-clip clothespin, affording a mild force for the initial work was used and was effective in the production of some motion and in the breaking up of the original resistance following which the response to further treatment became much more rapid. Figure 149 illustrates the clothespin with silver cuffs made with thin tips having sufficient width and concave gutters to rest against the cutting edges of several upper and lower teeth, thereby diffusing the force

FIG. 148.—Illustrating use of wooden oral screw in treatment of trismus.

FIG. 150.—Clothespin in position.

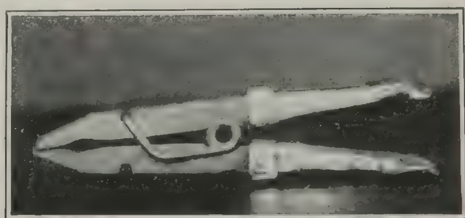

FIG. 149.—Spring clothespin with silver cuffs to fit between the teeth.

FIG. 151.—Rubber block used for wedging upper and lower teeth apart.

FIG. 152.—Illustrating separation of jaws by means of mouth gags.

so as to prevent soreness. These silver cuffs were made by molding the patterns in dental casting wax to be reproduced in silver by the usual casting methods. They were made to fit so that if the clothespin should break or become weakened they were interchangeable. Figure 150 shows clothespin in position. The use of this apparatus was intrusted to the patient with instructions to wear it for as many hours during the day as possible. Aside from the spring value, additional force could be made by pinching the ends of the pin together as much as the patient would stand; this broke up certain adhesions and the space thus gained was retained by spring. After the mouth had been opened as far as 10 or 12 mm. between the cutting edges of the incisor teeth and the jaws had acquired some motion it was the practice to provide an elastic medium for use between the teeth against which the patient could exercise the motions of the mandible. Nothing was more effective for this purpose than a soft rubber block. These blocks were made from rubber bottle stoppers, or vulcanized in suitable sizes from velum rubber; the ordinary rubber mouth gags made for use in the administration of gas oxygen were effective. Figure 151 shows a rubber block in the shape of a wedge which has been forced between the upper and lower teeth stretching the mouth as wide open as possible. The patient, by chewing against this block, caused a regular contraction and relaxation of the muscles, which, after contraction, received the rebound of the rubber. Permanent results were thus gained very rapidly. After equipping the patient with a rubber block, the mandible was subjected to quite an intensive positive force once a day. Figure 152 illustrates the use of mouth gags placed between the posterior ends of the arches on each side. By tightening these gags all that the patient could stand there was a certain separation of tissue fibers which could then be treated by the elastic forces.

FIG. 153.—Trismus apparatus assembled.

FIG. 154.—Illustrating individual parts of spring trismus apparatus to be worn constantly.

After the mouth was opened wide enough to procure casts of the upper and lower arches a regular apparatus was made which could be worn con-

stantly (Fig. 153). The impressions were taken in modeling composition and the casts poured in some form of artificial stone and mounted on an articulator. With ordinary pink base-plate wax, caps were molded over the teeth and reproduced by casting in silver. These caps fitted loosely on the teeth so that they could be easily inserted and removed, and were not cemented in position. A piece of 12 G. wire was threaded and a nut prepared for it. A piece of square wire of suitable size was soldered to one end. At the medial line on the upper appliance, at a point in a vertical line with the labial surfaces of the lower incisors, a piece of square tubing of about one-eighth inch in depth was soldered. A piece of 12 G. round tubing was soldered on the lateral surface of the lower cap at a point directly beneath the square piece of tubing on the upper, and this piece of round tubing was heavily reenforced. Pieces of 12 G. round tubing about three-quarters of an inch in length were split longitudinally, bent open, and soldered to the sides of the upper and lower caps, respectively, to form grooves at points opposite the premolar teeth. These tubes were heavily reenforced with solder. At the front ends of the groove holes were drilled so that by bending 12 G. spring German silver wire into the form of a U-shaped spring with one spiral curve in the base of the U, the forward ends of the spring would be bent at right angles so as to snap into the holes in the grooves, which prevented dislodgment of the spring. In Figures 154 and 155 are shown the five individual parts of the apparatus and the apparatus mounted. The patient was shown how to remove the appliance

Fig. 155.—Same apparatus mounted on model of jaws.

Fig. 156.—Illustrating use of orthodontic micrometer in measuring space gained in treatment of trismus.

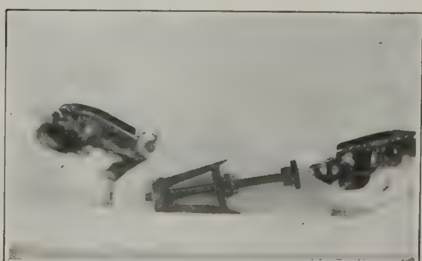

Fig. 157.—Showing details of another form of trismus appliance.

before meals, to be cleaned and replaced immediately after eating. With the exception of mealtimes, it was worn the entire 24 hours. Once a day the patient reported to the operator, and the jackscrew was placed in position by running the nut up on the threads, placing the end through the round tube on the lower cap. The square end was then brought up into the square tubing,

Fig. 158.—Same appliance as in Fig. 157.

Fig. 159.—Cast-aluminum trismus appliance furnished with jackscrews. Removable extension for holding modeling composition as support for skin graft in mouth.

Fig. 160.—Closure of jaws due to gunshot injury of left masseter muscle.

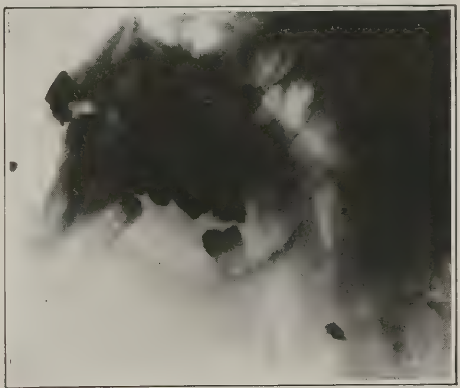

Fig. 161.—Radiograph showing missile and ossification in masseter muscle.

the nut tightened as much as the patient could stand and allowed to remain for 15 or 30 minutes before the jackscrew was removed. The looped springs were then tightened about 2 cm. wider than the existing space between the upper and lower caps so as to maintain the space gained by the jackscrew and at the same time to liberate slightly more spring pressure. When the appli-

ance was removed each day prior to stretching, an orthodontic micrometer was placed between the upper and lower incisor cutting edges at a definite point, and the record was kept from day to day in order to note the gradual progress. After the jackscrew had been used to stretch the jaws a second measurement was taken and recorded. The average case showed from 2 to 4 mm. improvement per day and the average length of time of treatment was usually about one month. If a greater period than one month was required it was evident that some serious mechanical handicap was present which perhaps would require surgical interference. It was estimated that 32 mm. space gained between the upper and lower incisor cutting edges was ample for all practical purposes (Fig. 156). Other forms of trismus appliances are shown in Figures 157, 158, 159.

In cases which did not respond readily to the gradual stretching process, and in which some obvious cause for the limitation of motion was present, operation for removal of the cause and to obtain full separation of the jaws was regarded as indicated. Operation in all cases was followed by the wearing of the spring apparatus and maintenance of the width of opening by means of the jackscrew for a varying length of time. Whenever possible, impressions were taken and the appliance made before operation, so that it would be ready for insertion immediately afterwards. In many cases operative interference proved useless owing to loss of time in inserting the appliance. Before resorting to operation the exact location of the restricting lesion was determined. If the cause was a foreign body, such as a piece of shell fragment, it was removed; if scar tissue due to loss of mucous membrane in the mouth, this was excised, the jaws stretched as far open as possible, and the raw surfaces covered with mucous membrane flaps from the cheek or lips or with Thiersch skin grafts; if muscular adhesions, the particular muscle fibers involved, whether masseter, temporal or internal pterygoid, were divided to permit of full opening.

Fractures in the region of the zygoma and coronoid process were particularly apt to be complicated by restricted movement of the mandible and at times required a thorough exploratory operation for the release of constricting fibers. In cases due to infection from septic teeth the offending teeth were removed. Figures 160 to 163 illustrate a case of limitation of motion and closure of the jaws due to a lesion in the region of the left masseter muscle. The patient was wounded by a small shell fragment which entered the face over the left malar process and traversed the masseter muscle, stripping up the periosteum over the outer surface of the ramus of the mandible. The radiograph (Figure 161) demonstrated a myositis ossificans of the masseter. The small shell fragment is seen at the posterior edge of the ramus. There was total inability to move the mandible. A semicircular flap incision was made over the ramus, and the entire ossified masseter muscle excised, permitting opening of the jaws to full extent. The trismus apparatus (see Fig. 155), which was inserted after the operation, maintained the space thus gained.

Figures 164 and 165 illustrate a case of limitation due to adhesions in the region of the internal pterygoid muscle. A high-explosive fragment passed through the right malar process, entered the internal pterygoid muscle, and lodged in the pharyngeal wall whence it extruded and was removed. The ankylosis was relieved by excision of dense scar tissue on the inner surface of the

Fig. 162.—Trismus appliance in place to maintain space gained by operation.

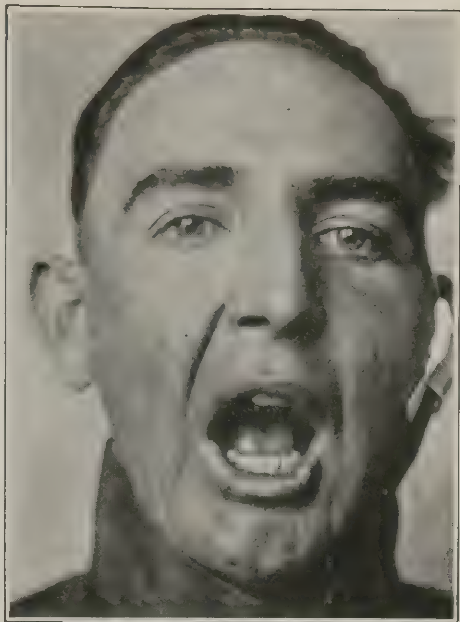

Fig. 163.—Result of treatment.

Fig. 164.—Limitation of motion of lower jaw due to gunshot injury in region of internal pterygoid muscle.

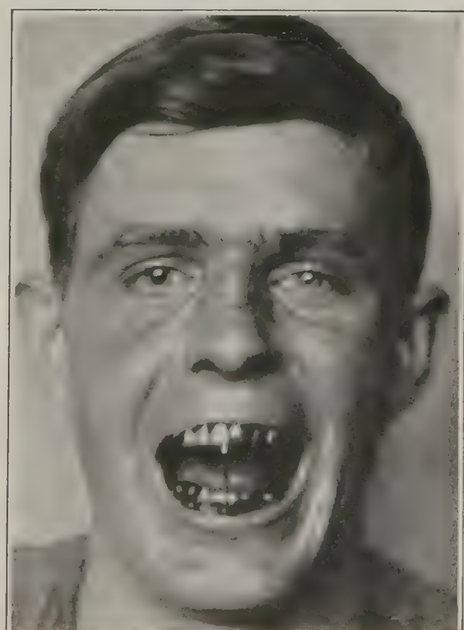

Fig. 165.—Trismus appliance in place after operation.

ramus, the operation being done through the mouth. The apparatus was then inserted and worn for several weeks with successful results.

Figures 166 and 167 are from a case of gunshot fracture of zygoma and coronoid process with extensive adhesion of temporal muscle. To relieve the ankylosis, a semicircular flap was turned downward and forward, exposing the condyloid and coronoid processes. Pieces of zygoma and coronoid process were excised and the neck of the condyloid divided, leaving the mandible freely manipulable. The combination spring and jackscrew apparatus had been made previously and was inserted immediately after the operation. Great improvement resulted from three months' treatment.

USE OF FREE SKIN GRAFTS TO REPLACE LOST MUCOUS MEMBRANE OF MOUTH.

When a missile penetrated the maxillofacial area and traversed the oral cavity the mucous membrane lining of the lips and cheeks was lacerated and the intercepting teeth torn out with an extensive loss of alveolar process and adjacent structures. As a result the raw surfaces were left in contact in such a manner that it was very difficult to prevent adhesions, and healing resulted in obliteration of the buccal and labial sulci. These adhesions did not usually interfere with such work as the adjustment of splinting apparatus for the reduction of fractures and were not brought to the operator's attention as a serious defect to be corrected until the wound had thoroughly healed and seasoned and all necessary repair had been completed up to the stage of inserting some form of prosthesis. There were a few exceptions to the above statement. One was the condition wherein these adhesions had to be primarily liberated in order to gain free manipulation in the overlying tissues for plastic operations on the lips or cheeks; another was the condition in which the adhesions caused limitation of the motion of the mandible. Formerly correction was attempted by incising through the adhesions and then inserting temporarily between the raw surfaces some foreign material such as gutta percha, modeling composition, or vulcanite. This method was generally unsatisfactory, the original condition, as a rule, returning very promptly.

Free skin grafting in the replacement of the mucous membrane of the mouth received an impetus during the war that carried it out of the class of operations which usually fail, and of what may be termed the "experimental stage," and established it as a definite procedure for which an almost positive assurance of success could be given.

Before describing the method employed, a brief review of other methods is given:

1. Free Ollier–Thiersch grafts have been tried in the mouth formerly, but have usually failed.

2. Mucous membrane flaps from other parts of the mouth: This is the method of choice, when there is sufficient membrane to spare, and there is no danger of producing contracture or shortening of the mucous membrane at the place from which the flap is taken.

3. The taking of a flap from the skin surface to replace oral mucous membrane is a difficult procedure, causing a large amount of scar tissue, and only too frequently the flap is hair bearing, which is a very disagreeable complica-

FIG. 166.—Gunshot fracture of zygoma and coronoid process with extensive adhesions of temporal muscle.

FIG. 167.—Trismus apparatus in position after operative treatment.

FIG. 168.—Diagram illustrating appliance for fixation of modeling compound bearing intraoral skin graft to epithelialize raw surfaces produced by division of adhesions and removal of scar tissue, reproducing buccal sulcus.

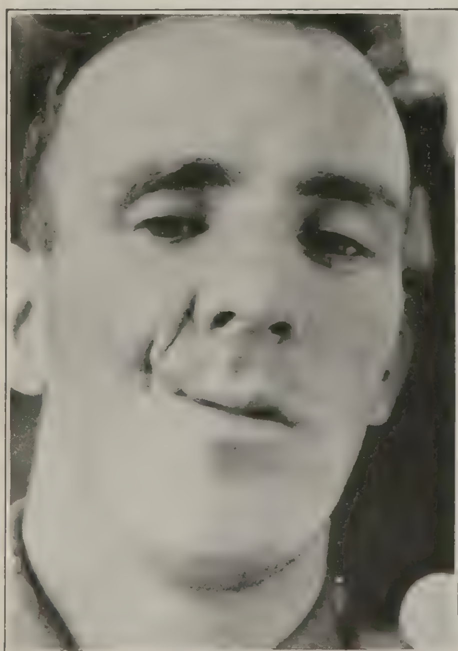

FIG. 169.—Scar involving corner of mouth.

tion. However, it has a place of decided importance in closing a large defect or in making an entire lip.

4. The free Ollier–Thiersch graft, held in place under pressure.

To Esser[12] belongs the credit for introducing the buried free skin graft. In seeking a means for applying Thiersch grafts evenly and keeping them immobile under equal pressure on the wound for several days, Esser conceived the idea of stretching the skin graft on an impression of the wound made in dental modeling composition, inserting this in the hollow of the wound, and suturing the edges of the wound over it. It is interesting to note the evolution of the present operation from this. To correct certain deformities or contractures in which there was a loss of mucous membrane, Esser incised the skin over the contracture, and dissected down to the contracture, but not into the

Fig. 170.—Same patient (Fig. 169), showing operative procedure.

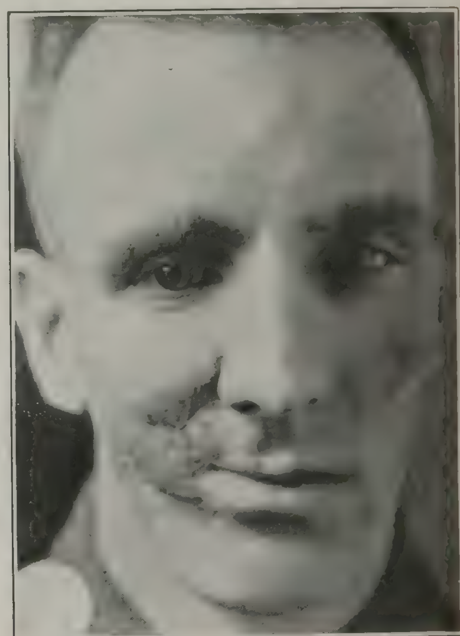

Fig. 171.—Same patient (Figs. 169 and 170). Operation completed.

mouth. Of this cavity he made an impression in modeling compound. Upon the impression he placed a Thiersch skin graft, with its raw surface out, and then introduced it into the cavity and sutured the skin edges over the compound. Ten days later he incised the scar tissue from within the mouth, and removed the compound, leaving the graft in place, lining the cavity which was then continuous with the mouth cavity.

Maj. Carl Waldron, of the Royal Army Medical Corps,[11] (Canadian Forces), working at the Queen's Hospital, Sidcup, England, modified Esser's procedure by dividing the scar tissue through the mouth instead of externally, making a cavity into which he introduced an accurate impression of modeling compound covered with a Thiersch graft. He then sutured the incision in the mucous membrane. The compound usually remained in place for several days, then came out or was removed, the graft, however, remaining as a lining for the cavity. The

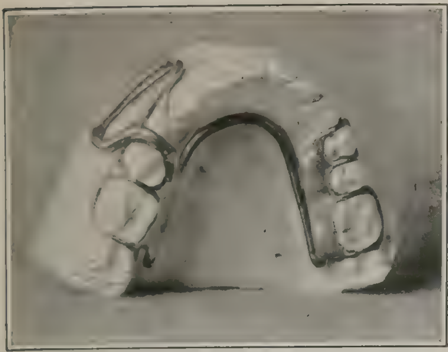

Fig. 172.—Adaptation of Jackson spring-clasp appliance for holding modeling compound bearing intraoral skin graft.

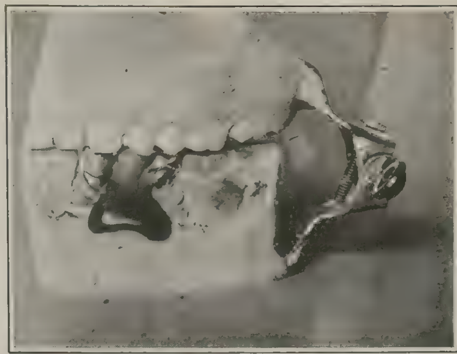

Fig. 173.—Permanent vulcanite prosthesis worn after lining buccal sulcus with skin graft.

Fig. 174.—Denture constructed with perforations to retain modeling compound for holding skin graft in position.

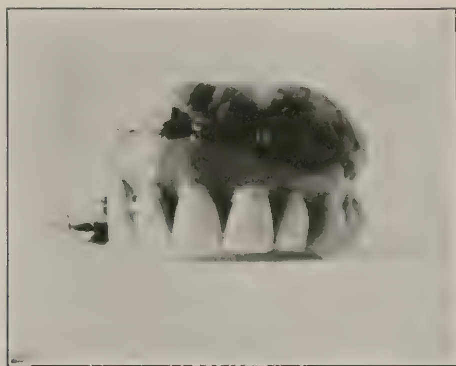

Fig. 175.—Shows modeling compound built on to denture.

Fig. 176.—Adhesion of upper lip to upper alveolar process, preventing wearing of denture and proper use of lip

Fig. 177.—Intraoral Thiersch graft covering raw surface after division of adhesions.

objection to this plan in many cases was that there was too much movement. The compound could not be kept in place as long as desired to prevent subsequent contracture. Members of the staff of the Queen's Hospital (Major Gillies, Major Waldron, and Major Pickerill) modified and improved Waldron's method by attaching the compound to a splint fastened to the teeth. In this manner the graft covering the compound was held firmly pressed in place. An impression of the cavity produced by dividing the scar tissue was taken in compound which was then attached to the splint, the compound being covered with a Thiersch graft and pressed firmly down in place. The compound was allowed to remain for ten days, and at the time of its removal, to avoid secondary contracture, was replaced by a vulcanite piece. This procedure was extensively employed by American maxillofacial surgeons. Dorrance,[13] advised thorough dissection of the scar tissue, enlargement of the cavity much beyond

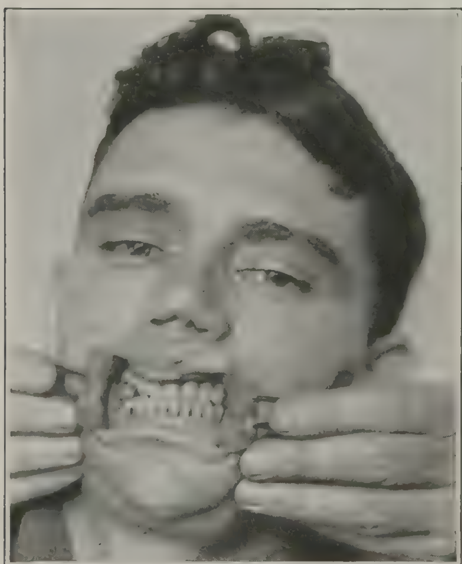

Fig. 178.—Permanent dentures in position (Figs. 176–177).

Fig. 179.—Permanent dentures in position with lips slightly apart.

what was desired, and putting the jaws in an open-bite splint (Figs. 168–171). The advantage of this splint was that it kept the mouth in one position and in an overcorrected one, so that the final result would not be interfered with by subsequent contracture. The original compound was retained in place for from fourteen to twenty-one days and its removal was always followed by the insertion of a vulcanite model and its retention for several weeks. Other devices were used for retaining the modeling compound. Figure 172 shows a Jackson spring-clasp apparatus with a wire loop for holding the modeling compound (Fig. 173). In Figures 174 and 175 is seen a denture constructed with perforations made for its retention. Another method was to place the graft over the edge of a previously constructed denture (Figs. 176–179).

The Thiersch grafts when first introduced in the mouth were pale in color, but several months later changed and became much the same as normal mucous membrane.

LOCALIZATION AND REMOVAL OF FOREIGN BODIES IN MAXILLOFACIAL REGION.

The removal of foreign bodies, such as bullets, portions of hand grenades, high explosive and other missile fragments, was frequently attended by some of the most baffling complications presented in the treatment of maxillofacial injuries.

This work was distinctly divided into two stages: (A) Immediate removal from fresh wounds; (B) removal from healed wounds.

In the majority of cases, all missile fragments were removed before return of the patients to the United States, but in a few instances they were overlooked or purposely allowed to remain until the patient reached a hospital in this country.

Early operation, as a rule, was much simpler, for the conditions usually presented to the surgeon afforded definite localization through the open tract, ready means of direct ingress, ease in grasping the object and in its removal. For one to be an expert in this work, however, an absolute mastery of the regional anatomy was essential, thus affording the ability to extract the missile through some shorter tract opened to it than the path through which it entered, as well as to prevent the dangerous liabilities of nerve, vessel, and muscle severance and its resultant complications.

The removal of foreign bodies after a wound was healed presented much greater difficulties than were encountered in unhealed cases, because of the fact that localization must be gained out of obscurity.

The successful localization of foreign bodies usually resulted from the combination of a careful physical examination of the patient, the detection of sensory or motor nerve abnormalities, and the use of the X ray. In the careful physical examination of the region the point of entrance of the missile was taken into account, together with the statement of the patient, and a study of the regional anatomy usually resulted in imparting a reasonably definite idea of location to within perhaps 1 inch of the exact spot. After having reached a conclusion by this preliminary examination, the patient was questioned as to any abnormal sensations felt from time to time under varying conditions, and if there had been any nerve severance, a test of the field supplied by the nerve in question usually revealed some point of evidence as to the location of the offending agent.

In employing the X ray, one of three methods was pursued: (A) Localization by simple radiographs focused at cross measurements; (B) localization by stereoscopic radiographs; (C) localization by means of fluoroscopy.

Simple localization of the presence of the opaque object on the radiographic plate meant very little, and those who relied on this usually met with failure for the following reasons: Owing to inability to place the head in a definite position, the plane of the surface of the X-ray plate, the angle of the X ray, cast from the target, and the long axis of the tube could not be adjusted on such a basis of exactitude as to reflect the object in a constant position and even though several views were made, the variance between them could not be taken as an average for anything definite.

Stereoscopic plates mounted in an accurate stereoscopic apparatus often revealed a very definite localization, but the clinical follow-up of these findings did not always result successfully. Therefore the final and accurate means of localization was usually the fluoroscopic screen.

There were two satisfactory methods of procedure in the use of the fluoroscope in localization of foreign bodies in the maxillofacial region, the choice having to be determined largely by the equipment available, the surroundings, and the degree of seriousness of the operation to be performed. If the missile was not at great depth, and if a rigid sterile technique was not essential, it was possible to inject the field with a local anesthetic and, by locating the object with exploratory needles thrust against it while under the fluoroscope, an incision was made and the object dissected out while under full view at all times. This method was followed in the majority of fresh wounds where infection was already present or expected. It was more risky in healed wounds, because of the fact that aseptic technique under the fluoroscope, with the average equipment available, was difficult, and there was likelihood of serious infection.

FIG. 180.—Case 13: Anteroposterior radiograph.

A very effective plan was to place the patient beneath the fluoroscope, and, by means of an indelible marker, to make a spot on the skin surface immediately over the shadow of the foreign body with the head placed in an exact anteroposterior position; then, by placing the head in an accurate lateral position, to make another spot with the marker. The patient was then taken to the operating room, where proper preparations had been made. After anesthetizing the patient long needles were thrust in the correct lines through the spots marked on the skin, and their point of convergence would usually strike the object, which could be very readily detected by tactile sense.

As a rule, every effort was made to extract a missile in this region intraorally by incising the mucosa and establishing a tract leading to the foreign body by blunt dissection. Infection, while liable to occur, was not dangerous if the proper postoperative treatment was followed. After removal of the foreign body, which was usually grasped with a hemostat, the tract was packed with a strip of rubber tissue, permitting irrigation for several days with normal saline.

The following cases illustrate the use of some of these methods in the localization and removal of missiles as practiced at the Walter Reed General Hospital:

CASE 13.—2d Lieut. M. R. B. Wounded December 18, 1918, at Proving Grounds, Aberdeen, Md. A high-explosive fragment struck the glabella, penetrated the left eye, necessitating its enucleation, and lodged in such a position as to cause inability of the patient to open his mouth

more than 3 cm. Figure 180 is an anteroposterior radiograph which locates the fragment as though it were lodged somewhere between the inner surface of the ramus and the sphenomaxillary fossa. Figure 181 is a lateral radiographic view showing location of fragment near the anterior border of the ramus of the mandible and probably between it and the tuberosity of the maxilla. The radiographs were sufficiently accurate and the fragment was readily located and removed intraorally under local anesthesia. The fragment was lodged squarely in the internal pterygoid muscle and the contraction of the scar tissue caused the trismus. By the adjustment of the usual trismus apparatus, full motion was readily and permanently restored.

Fig. 181.—Case 13: Lateral radiograph.

Case 14.—2d Lieut. J. J. S., Co. A, 126th Inf. Wounded August 1, 1918, at Chateau Thierry. High-explosive fragment entered right side of nose, taking a course backward and to the left, and lodged in the face at some point in front of the cranium, giving unusual nerve disturbance and interference with motion of lower jaw. Figure 182 is a lateral radiograph showing the fragment somewhere in the region of the coronoid process and zygoma or at some point deeper. Figure 183 is an anteroposterior view, revealing the fragment apparently located inside the ascending ramus of the mandible and somewhere beneath the malar process and arch of zygoma. An attempt at exploration with no further effort at localization resulted in failure. A similar result followed exploration after stereoscopic plates had been made. The patient was then placed under the fluoroscopic screen and indelible marks made on the face over the shadow of the foreign body in the lateral and anteroposterior positions, as shown in Figure 184. Under local anesthesia the spots on the skin were pierced with long needles and the fragment found by the needle thrust through the parotid region was located immediately posterior to and behind the greater wing of the sphenoid at a point some distance from its apparent location in the radiographs. The fragment was removed intraorally, the wound was drained and irrigated, healing without complication.

Fig. 182.—Case 14: Lateral radiograph.

Case 15.—1st Sgt. J. E. E., Co. A, 12th M. G. Bn. Wounded in the Argonne, October 5, 1918, by a high-explosive fragment, which entered the right ear, taking a transverse course, passed beneath the zygoma, fractured the head of the condyle of the mandible, entered the maxilla through the right tuberosity, and finally lodged in the left side of the face. Figure 185 illustrates paralysis of right side of face, due to severance of seventh nerve. Figure 186 is an anteroposterior

FIG. 183.—Case 14: Anteroposterior view.

FIG. 184.—Case 14: Showing indelible marks made on face under fluoroscopic screen.

FIG. 185.—Case 15: Showing right-sided facial paralysis.

FIG. 186.—Case 15: Anteroposterior view of fragment.

radiographic view showing fragment located somewhere on a line drawn through left maxillary sinus. Figure 187 is a lateral view showing fragment somewhere in region of left maxillary tuberosity near posterior superior border of palate. This was a case in which stereoscopic plates revealed so unquestionably the fact that the missile was resting partly in the left maxillary sinus and partly projecting through the tuberosity into the sphenomaxillary fissure that fluoroscopic localization was not considered necessary. Under local anesthesia the left maxillary third molar was extracted and the missile removed after enlarging the socket of this tooth with a surgical burr. The maxillary sinus had presented no symptoms of infection; it was packed, irrigated, and healed readily.

Fig. 187.—Case 15: Lateral view of fragment.

PLASTIC OPERATIONS ON SOFT TISSUES OF FACE.

The simplest form of healed defect which required treatment was a depressed scar remaining at the site of entrance or exit of a missile. The scar tissue often caused the skin to be adherent to the underlying periosteum. In the treatment of such a condition all visible scar tissue was first excised and the overlying tissue freely mobilized from the periosteum. The skin edges were undermined so that they could be brought together without tension. If the edges of the wound had been simply approximated, edge to edge, a return of the depression might have resulted, owing to re-contraction of scar tissue during healing. This was avoided in simple cases by employing a vertical mattress or Lembert suture for the skin whereby broad raw surfaces were brought together, somewhat puckering out the line of suture. Then as healing occurred, the suture line would gradually return to the normal skin level instead of below it. When originally there had been a noticeable amount of tissue destruction at the site of the scar, the depression was filled out by partially loosening the subcutaneous fat in the neighborhood, drawing it into the defect and suturing it with buried catgut. Then the skin edges were brought together. Where local subcutaneous fat could not be obtained in sufficient quantity to fill in the depression, free transplants of abdominal fat or of fat and fascia lata from the thigh were employed. The skin, and preferably a deeper layer of subcutaneous tissue, were undermined sufficiently to create a pocket for the reception of the fat and fascia transplant, which was attached in place by means of buried catgut sutures. The subcutaneous tissue and skin were then closed in separate layers over the graft. Various skin suture materials were employed, including silk, horsehair, silkworm gut, and "dermal suture." The last proved more uniform and stronger than horsehair and softer than silkworm gut.

If the excision of scar tissue resulted in a wound with edges which could not be brought together without tension, or whose shape was markedly irregular, some form of flap closure was resorted to. No two cases were exactly alike, and the ingenuity of the operator had to be exercised in dealing with each to the best advantage.

By flap closure is meant the utilization of tissue obtained by making incisions additional to those of the original wound. Sliding flaps were obtained by extending the incisions in various directions from the original wound and drawing the flaps thus released over the defect. In other cases a skin flap was raised at some more or less distant point, carried over and sutured into the defect, but left attached by a pedicle at its original site until the establishment of new circulation, after which the pedicle was severed and replaced in its original bed. As ordinarily employed, the length of a pedicled flap was not more than three times its breadth; otherwise sloughing sometimes occurred. Again, the skin defect was filled by a free transplant of skin, either a full thickness or Wolfe graft, or a graft consisting of the epidermis alone—the Ollier–Thiersch graft.

When a wound of the soft tissues of the face resulted in displacement of features, such as the eyelid, the angle of the mouth, or the vermilion border of the lip, the parts involved were freed by detachment of scar tissue in such a manner that they could be returned to their normal positions and held in place by such disposition of flaps as was necessary. In defects involving the full thickness of the cheek it was necessary to replace the lost mucous lining as well as the skin. This was accomplished in several ways; one way was to turn over a flap of skin with a hingelike pedicle at the edge of the defect so that the skin surface faced the mouth. Then a second pedicled skin flap was taken to cover the raw surface. Another method of furnishing a lining was to use pedicled or sliding flaps from the neighboring oral mucous membrane. A third method was to raise a pedicled skin flap of suitable size and shape to cover the outside of the defect and epithelialize its under surface, with a Thiersch graft before transfer to its new position. This last method did not generally prove so satisfactory as either of the first two. Where a defect existed with loss of bony support, as well as absence of skin covering and mucous membrane lining, as in the nose, it was necessary to support by means of a cartilage or bone graft inserted between the lining and the covering (See Injuries to the Nose, p. 522).

In transferring large pedicled skin flaps from a distance, due attention had to be given to insuring a proper blood supply. This was done in some cases by having a large artery, such as the superficial temporal or the facial, enter the pedicle. At other times a double pedicled flap was employed.

"TUBING" THE PEDICLE.

This method was devised by Maj. H. D. Gillies,[11] of the Royal Army Medical Corps, and was adopted to some extent in our hospitals. It consisted in preparing the pedicle by making two parallel incisions from 2 to 3 inches apart, raising the skin between them, closing the defect by bringing its edges together after undermining, and then suturing together the parallel edges of the pedicle so that the latter assumed the form of a tube with skin surface outward. By this procedure the flap gradually gained its main blood supply through the pedicle, and a much larger flap, obtained from a greater distance, could be utilized. As practically no raw granulating surface was exposed, the wound, as a rule, remained much cleaner than where the ordinary pedicle was employed. After 10 days to 3 weeks the flap was raised and transferred to the defect to be filled.

Extensive observations by Blair in the making and transplanting of cutaneous flaps for the correction of superficial defects led to the following conclusions: [11]

1. That about the neck and face of a man in ordinary health, regardless of age, rather long flaps could be made with little danger to their vitality provided the return circulation was obstructed by neither gravity, kinking, nor torsion of the pedicle.

2. That in any instance the chance of success was increased, a longer flap could be raised, or the flap could be cut narrower and thinner with equal chance of success if it was first completely raised and then immediately sutured back into its original bed, the transfer to the new position being delayed for a period varying from 6 days to 2 weeks.

Fig. 188.—Extensive mutilation of upper lip.

Fig. 189.—Scar involving right corner of mouth.

3. That if a flap sloughed in its original bed, the extent of the area lost was considerably less than if it had been immediately transplanted.

4. That sloughing of an untransplanted flap was apt to be superficial without destruction of the full thickness of the skin, while a slough occurring after transfer was more apt to involve the full thickness of the flap.

5. That if a flap would not survive, it was a real advantage to have this fact demonstrated before removal of the scar and freshening of the edges of the defect.

6. That provision for a possible partial loss could usually be made in the original planning of the flap.

7. That if it became evident that the transplanted flap was in danger of sloughing, it was better immediately to place it back in its original bed. By so doing not only was time saved but, usually, a much larger part of the flap.

8. That a blood clot under a flap that had been sutured back into place might be fatal to the flap. This was avoided by moderate pressure of dressing, and by the use of multiple drains, removed in 24 hours.

Fig. 190.—(a) Lines of excision of scar tissue and outline of flaps. (b) Wound after excision of scar tissue and preparation of the flaps. (c) Lines of suture; descending flap to raise corner of mouth (Figs. 188–189).

Fig. 191.—View of patient after operation (Figs. 188–190).

Fig. 192.—Side view of same patient after operation.

Fig. 193.—Large depressed scar of lower lip and chin.

Fig. 194.—Another view of same patient.

9. That by this procedure certain complicated, time-consuming operations were advantageously divided into two sittings.

10. That occasionally, after suturing the flap back into its original bed, the transplantation would of necessity be long delayed by a low-grade suture infection or an infection in the bed. Either of these occurrences was an incident rather than a calamity and had to be guarded against by not drawing the sutures tight, by removing them early, and by free drainage and ordinary cleanliness.

11. That when any part of the flap sloughed while in its original bed, that part, no matter how superficial the slough, should not be transplanted.

The accompanying illustrations are from cases depicting some of the principles described.

Figures 188–192 are from a case of extensive mutilation of the upper lip and right corner of the mouth. Figures 188 and 189 show the patient after healing of the original wound. Figure 190 is made from drawings to illustrate (*a*) lines of excision of scar tissue and outline of flaps; (*b*) wound after excision of scar tissue and preparation of flaps; (*c*) lines of suture; descending flap to raise corner of mouth. Figures 191 and 192 show the patient after operation.

Figures 193 and 194 show a large depressed scar of the lower lip and chin remaining after healing of wound of exit of a high explosive fragment. Note drawing down of corner of mouth. Figure 195 shows (*a*) wound after excision of scar and outline of pedicled neck flap; (*b*) neck flap turned at right angles and sutured into chin wound; (*c*) closure of neck wound. Figure 196 is a photograph made shortly after removal of the sutures.

Figures 197 to 204 show stages and results of treatment of a case from aavanced hospital to final treatment in the United States. Figure 197, taken shortly after wound was incurred, pictures the complete destruction of upper jaw and right side of upper lip by high-explosive fragment. Figure 198 is another view of same case. Figure 199 shows early attempt at conservation of fragments of upper jaw and support of soft tissues by "Amex casque." Figure 200, condition on arrival in United States, six months after injury. All that remains of the upper jaw is a loose fragment of alveolar process of left side, containing a few teeth. The mouth and nose form a common cavity. Figure 201 shows the condition of the upper lip at this time. It became necessary to remove the portion of alveolar process and teeth remaining, leaving the patient with no bony support for a future obturator. Figure 202 shows plaster of Paris head cap with supports for palate obturator and nasal splints, pending the preparation of a permanent obturator. Figures 203 and 204 were taken after plastic repair of the upper lip. This consisted in excision of scar tissue, and preparation of flaps by extending incisions transversely into right cheek and toward nose.

Figures 205 to 214 are from a case of total loss of upper lip and anterior portion of hard palate, illustrating the use of double pedicled flap from scalp. Figure 205 shows the patient before operation. The double pedicled flap was raised from the vertex of the skull, and its under surface epithelialized by a Thiersch graft. Two weeks later the flap, with a pedicle from each temporal region, was brought down and sutured to form the upper lip, as shown in Figure 206. Figure 207 shows pedicles severed and returned to scalp. Figure 208

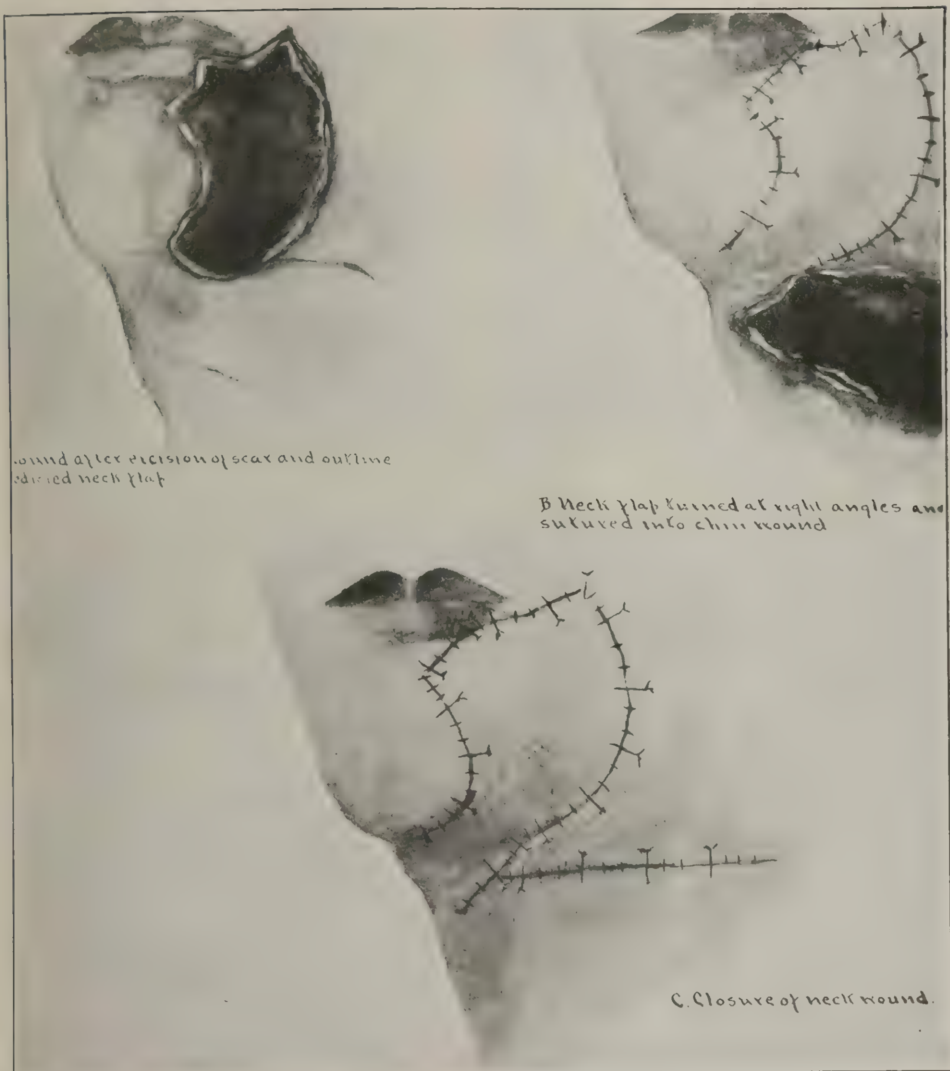

FIG. 195.—(a) Wound after excision of scar and outline of pedicled neck flap. (b) Neck flap turned at right angles and sutured into chin wound. (c) Closure of neck wound.

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Fig. 196.—Same case (Figs. 193–195) shortly after removal of sutures.

Fig. 197.—Photograph taken shortly after receipt of wound by high-explosive fragment causing complete destruction of upper jaw and right side of upper lip.

Fig. 198.—Another view of case (Fig. 197).

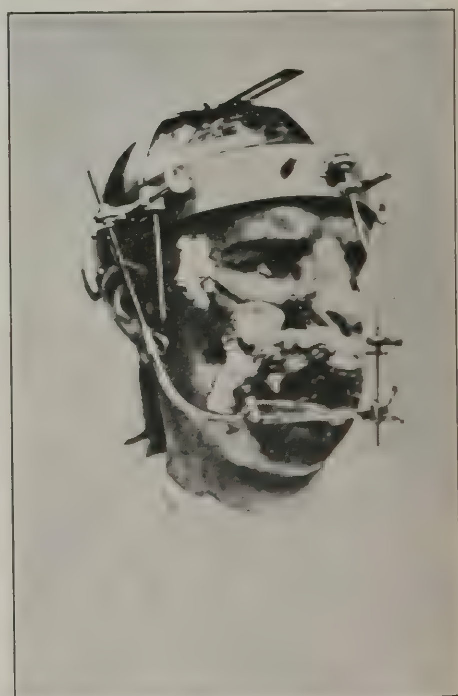

Fig. 199.—Early attempt at conservation of fragments of upper jaw and support of soft tissues by "Amex" headgear.

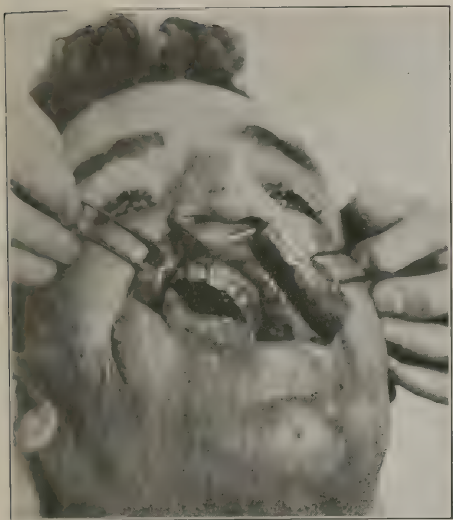

FIG. 200.—Condition on arrival in United States six months after injury. Shows remaining loose fragment of alveolar process with teeth.

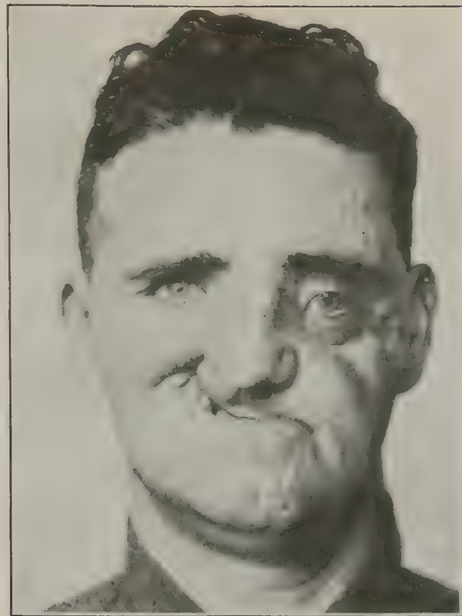

FIG. 201.—Showing condition of upper lip at same time.

FIG. 202.—Plaster of Paris headcap with supports for palate obturator and nose, pending the preparation of a permanent obturator.

FIG. 203.—After repair of upper lip.

Fig. 204.—A later view of same case (Figs. 200–203).

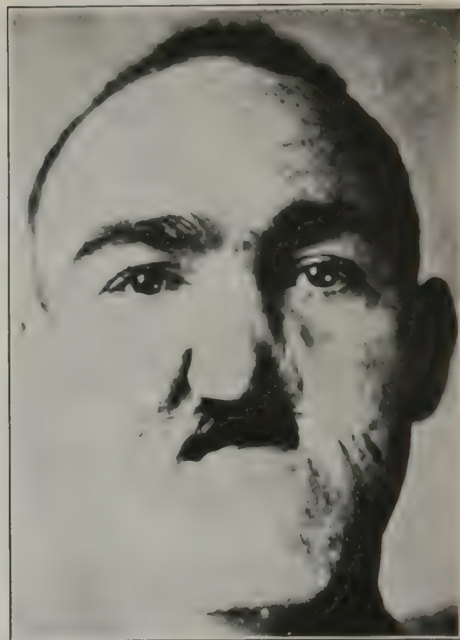

Fig. 205.—Total loss of upper lip and anterior portion of hard palate.

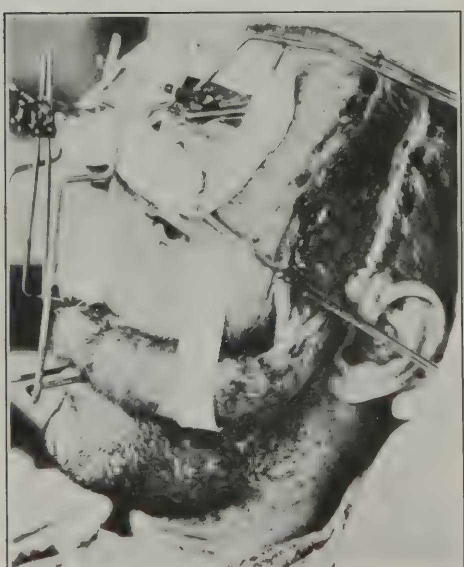

Fig. 206.—Double-pedicled scalp flap brought down and sutured to form upper lip.

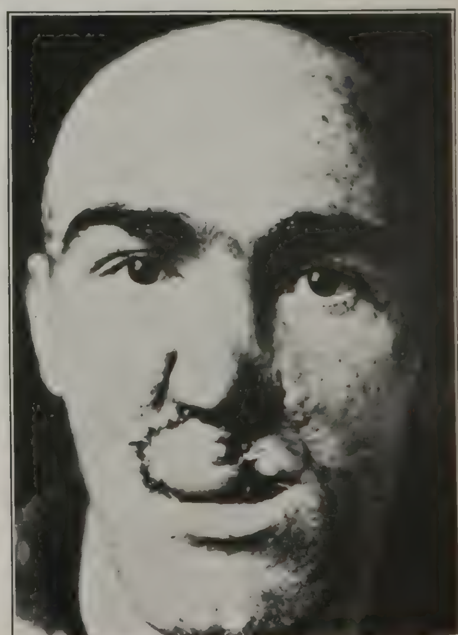

Fig. 207.—Pedicles severed and returned to scalp.

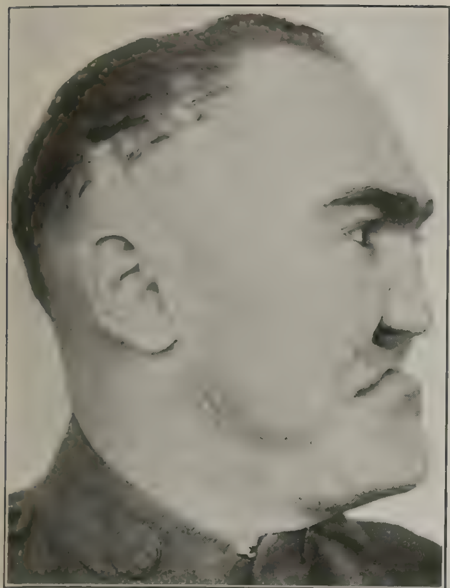

FIG. 208.—Condition after further plastic work (Figs. 205–207).

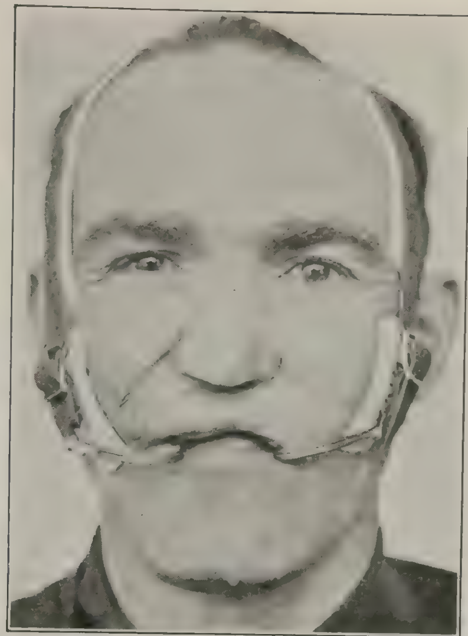

FIG. 209.—Same patient with temporary palate obturator in place.

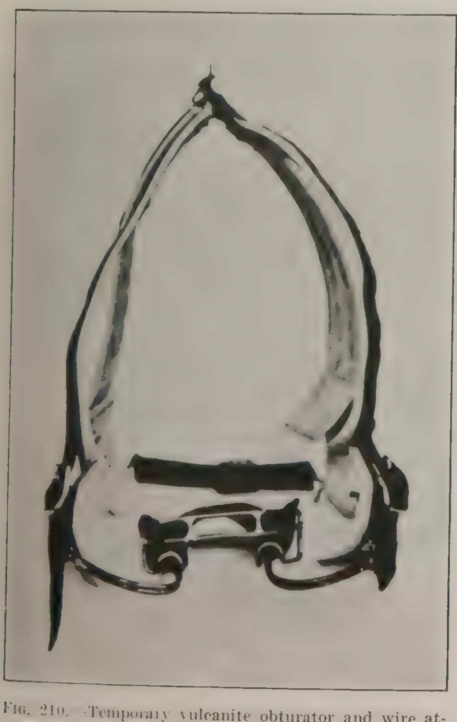

FIG. 210.—Temporary vulcanite obturator and wire attachment for modeling composition to build out lip.

FIG. 211.—Patient wearing temporary obturator and lip support of modeling composition.

illustrates the case after further plastic work. Figure 209 shows patient with temporary palate obturator in place. Figure 210 temporary obturator and wire attachment for modeling composition to build out lip, attached by vertex strap. Figure 211, patient wearing temporary obturator and lip support. Figures 212 and 213, permanent obturator with artificial teeth and extension to replace lost columella. Figure 214, complete case.

Fig. 212.—Details of permanent obturator with artificial teeth and columella.

Fig. 213.—Same apparatus assembled.

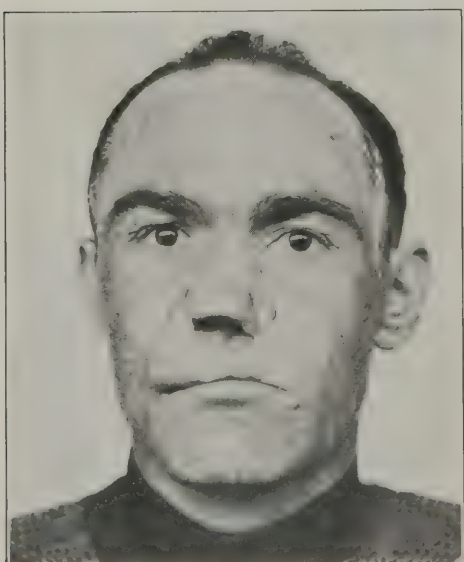

Fig. 214.—Completed case (Figs. 205–213).

Fig. 215.—Large depressed scar of right cheek.

Figure 215 shows a large depressed scar of the right cheek, with adhesions to the bone. Figure 216 is from drawings to show steps of fat transplanting operation: (*a*) appearance before operation, (*b*) lines of excision of scar, (*c*) placing of free fat from abdominal wall, (*d*) lines of skin suture. Figures 217 and 218 show the completed case.

Figures 219 and 220 illustrate a case of large depressed scar of right cheek treated by excision of scar and transplant of fascia lata from right thigh.

Fig. 216.—(a) Appearance before operation. (b) Lines of excision of scar. (c) Placing of free fat from abdominal wall. (d) Lines of skin suture.

FIG. 217.—Completed case (Figs. 215–216).

FIG. 218.—Another view of completed case.

FIG. 219.—Large depressed scar of right cheek.

FIG. 220.—After excision of scar and filling of depression with fascia lata.

The following three cases were reported from General Hospital No. 2, Fort McHenry, Md.

Figures 221, (*a*), (*b*), and (*c*), illustrate a defect of the lower lip and chin with loss of 2½ inches of mandible at symphysis. Repair by flaps from neck and cheeks. A few spicules of bone remained in the soft tissues between the ends

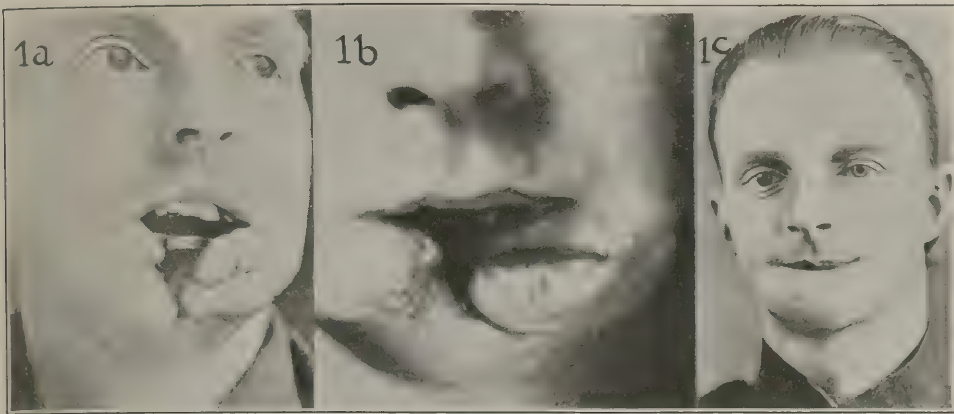

Fig. 221.—(a) Defect of lower lip and chin with loss of 2½ inches of mandible at symphysis, showing bar splints attached to teeth in lateral segments. (b) Later stage of case. (c) Same case after repair by flaps from neck and cheeks.

Fig. 222.—Loss of entire content of right orbit, both lids and part of orbital border. Note tubed pedicle along right side of neck for flap from chest.

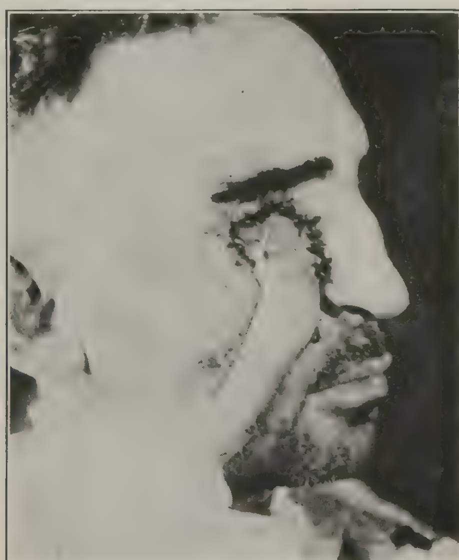

Fig. 223.—Flap from right side of chest with tubed pedicle carried to repair orbit.

of the mother bone. These were carefully left in place. After reconstruction of the chin and lip, the X ray showed that these spicules had developed into a solid shaft of bone, uniting the ends of the broken mandible very firmly. No bone graft was needed. Photographs show appearance before and after operation.

Figures 222 to 226 are from a case of loss of entire content of right orbit, partial loss of lower and upper orbital border, and loss of both lids. Repair by flap from right chest carried to place by tubed pedicle. The intention was to split this pad of skin and to epithelialize the under surfaces so that an artificial eye could be worn. As it was not possible to do this in a short time, a prosthesis was made of vulcanite with artificial eye incorporated, and attached to spectacle frames.

In the case shown in Figures 227 to 236 there was a complete loss of all tissue from the angles of the mouth to the larynx, including lower lip, chin, five inches of jaw, and floor of mouth. Repair of the soft tissues was brought about by double epithelialized flaps from the right chest, and later by double flaps from the cheeks. To supply additional lining for the floor of the mouth a large flap was cut from the left side of the neck and inverted. Five inches of rib were later grafted into the jaw, the rib being bent to conform to the normal curve of the symphysis. This was successful in giving a solid jaw, with very good natural movement. As this man had in all about 33 operations, besides going through a severe attack of erysipelas, later an equally severe attack of diphtheria, and still later scarlet fever, he was discharged with the promise that in a year or two he would return as a beneficiary of the Veterans' Bureau, for whatever further plastic work might be necessary.

Figures 237 to 243 are from a case treated at the Walter Reed General Hospital, the lesions being caused by a phosphorus burn. There was total destruction of the left ear, extensive scarring of the face and neck and loss of the left eyebrow. The amount of scar tissue in the neighborhood did not permit surgical reconstruction of the ear, and an artificial substitute was provided in vulcanite. The eyebrow was reproduced by a pedicled flap from the edge of the scalp, brought down and sutured into a defect made by excising scar tissue over the left eye. The pedicle was later severed and returned to the scalp. The cosmetic result was very good. It was necessary, however, for the patient to keep the new eyebrow trimmed so as to correspond to that on the right side.

Extensive defects of the external ear are very difficult to repair with reproduction of the natural appearance. Repair of the deformity shown in Figures 244 to 247 was attempted by insertion of costal cartilage beneath the skin immediately above the remaining portion of the ear. The skin flap containing the cartilage was later raised and sutured to the upper edge of the ear defect, the raw surface behind being covered with Thiersch graft supported on dental impression compound. A result approximating the normal was obtained.

The following cases were treated in the maxillofacial center at the post hospital, Jefferson Barracks, Mo.

Figures 248 to 251 show scarring from shell wound that destroyed parts of cheek, chin, lower lip and a section of the lower jaw. In the repair of the soft parts the chief scars in the cheek were excised and the tissues undermined until the skin could be smoothly sutured without a depression. A flap was cut from the cheek adjacent to the lip and nose. The part of the flap above the dotted line included skin and some subcutaneous tissue, below the dotted line the full thickness, including the mucosa, was taken with the flap. An incision was made along the mucocutaneous junction, bordering the defect and the mucosa was dissected up so as to permit the implantation of the flap.

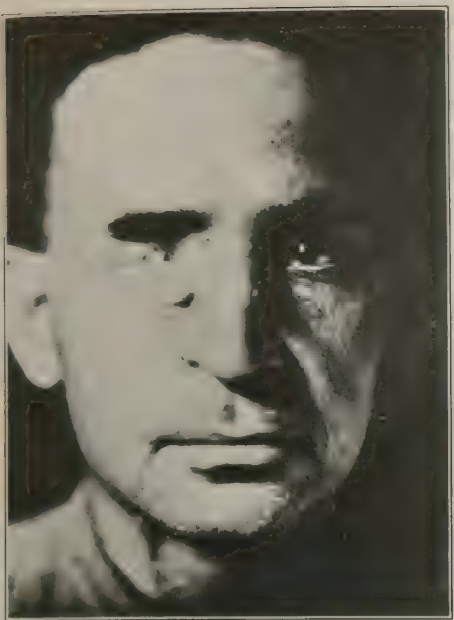

Fig. 224.—Same case (Figs. 222–223) after cutting pedicle and returning to neck.

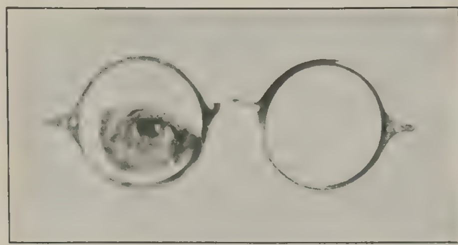

Fig. 225.—Prosthesis made of vulcanite with artificial eye incorporated, attached to spectacle frames.

Fig. 226.—Patient wearing prosthesis.

Fig. 227.—Complete loss of all tissue from angles of mouth to larynx, including lower lip, chin, 5 inches of mandible, and floor of mouth. Photograph taken at Base Hospital 115, A. E. F.

FIG. 228.—Same case (Fig. 227) after healing and before reconstructive operations.

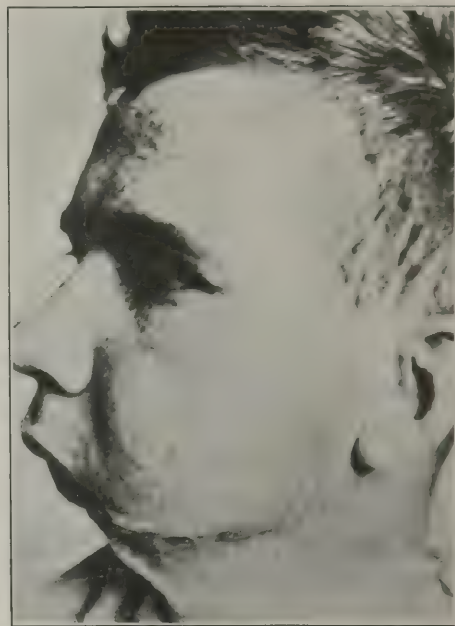

FIG. 229.—Profile view of same patient.

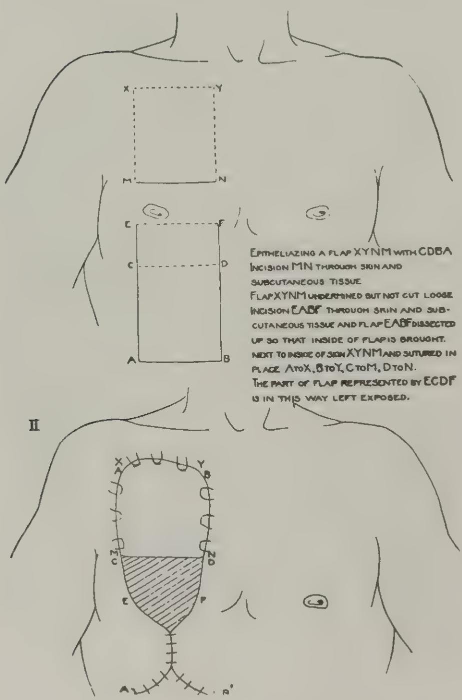

FIG. 230.—Diagrams explaining preparation of chest flaps to repair chin.

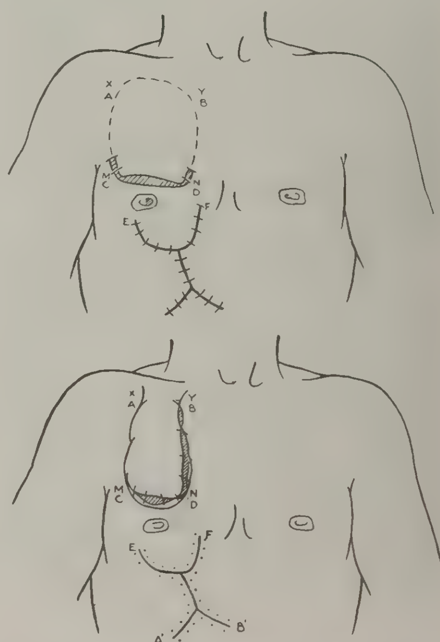

FIG. 231.—Diagrams showing further stage of preparation of chest flaps.

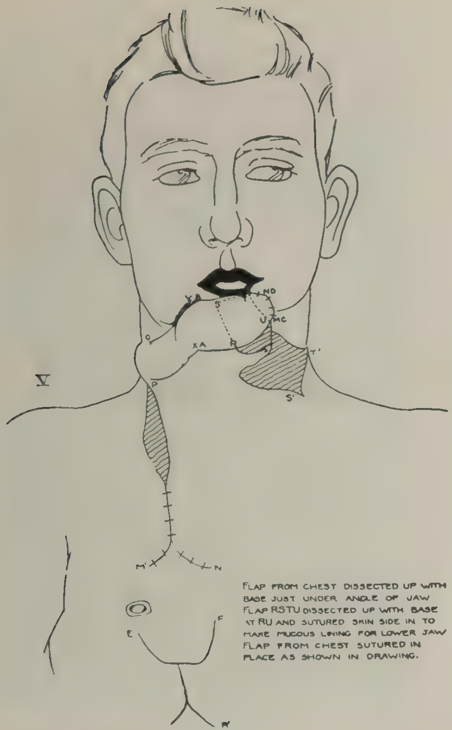

FIG. 232.—Diagram showing pedicle flap from chest sutured into chin defect (Figs. 227–231).

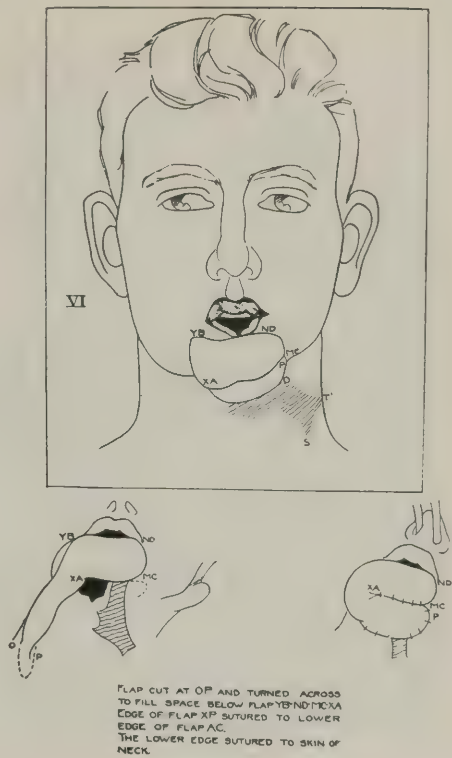

FIG. 233.—Diagrams showing further stage of chin plastic.

FIG. 234. Photograph of patient after suture of chest flap into chin defect and return of pedicle to chest.

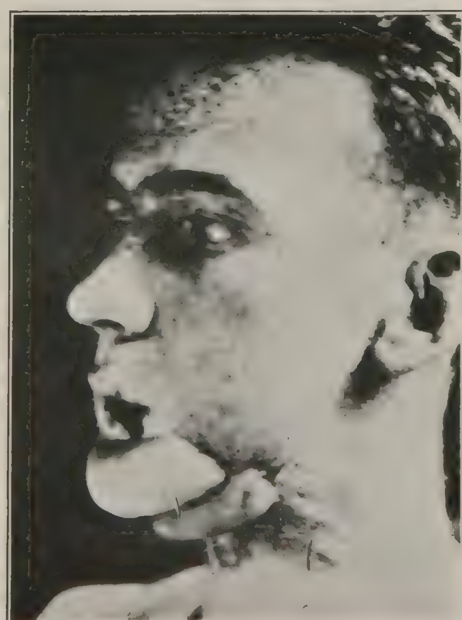

FIG. 235.—Profile view of same stage as shown in Fig. 234.

FIG. 236.—As patient appeared when discharged (Figs. 227–235).

FIG. 237.—Total destruction of left ear and left eyebrow from phosphorus burn.

FIG. 238.—Profile view of same case shown in Fig. 237.

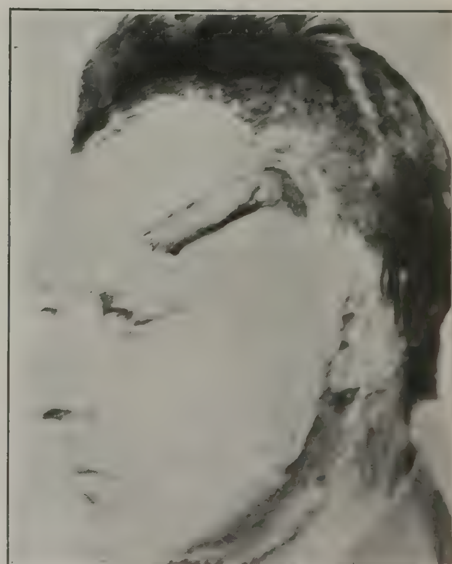

FIG. 239.—Pedicle flap from edge of scalp brought down and sutured into raw surface of brow. Note temporary loss of hair on end of flap.

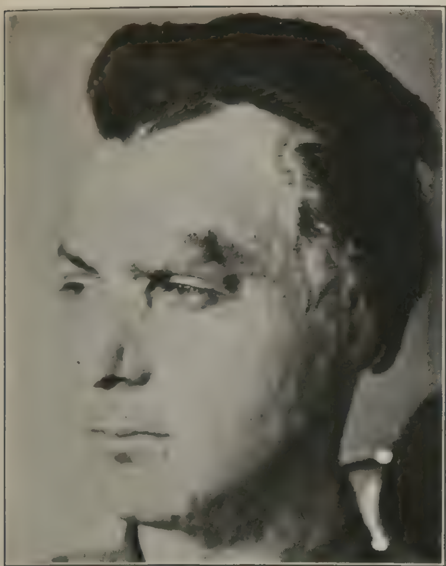

Fig. 240.—Pedicle severed and returned to scalp (Figs. 237–239).

Fig. 241.—Later view of same patient, showing growth of hair on left brow, and unfinished artificial ear in place.

Fig. 242.—Later view of same patient, showing growth of hair on brow and finished vulcanite ear fastened in place.

Fig. 243.—Side view of same patient.

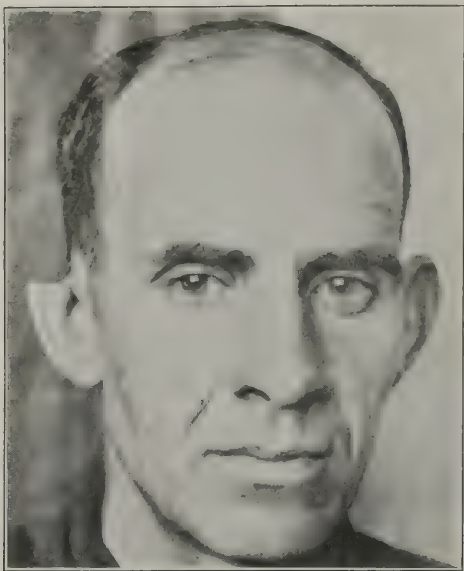

FIG. 244.—Loss of upper portion of pinna.

FIG. 245.—Piece of costal cartilage shaped to supply ear defect and inserted beneath skin immediately above remaining portion of ear.

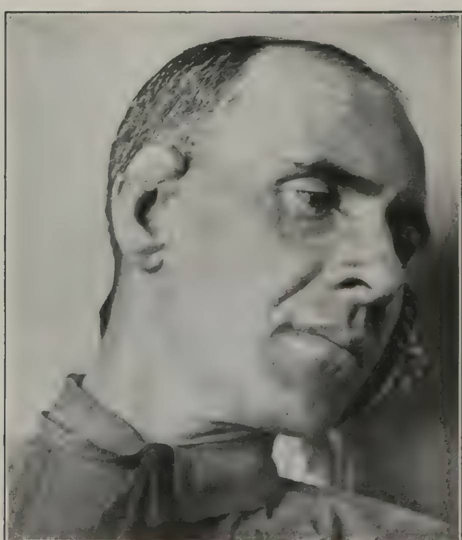

FIG. 246.—Same case after raising scalp flap containing cartilage and suturing it to upper edge of remaining portion of ear.

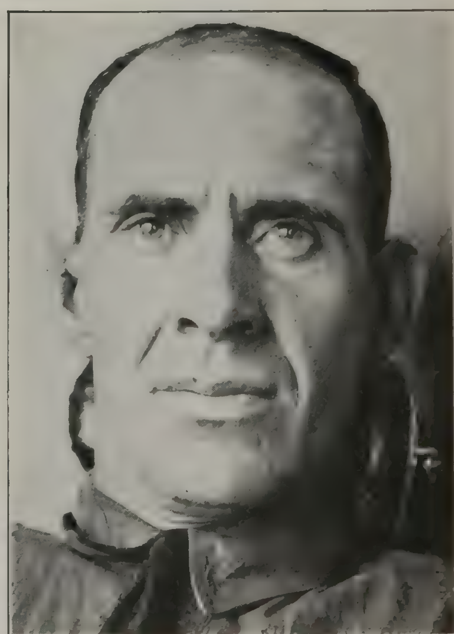

FIG. 247.—Another view of same case.

Figures 252–254 show simple excision of a broad scar and repair of the defect. Where the scar was irregular in shape it was desirable to so plan the

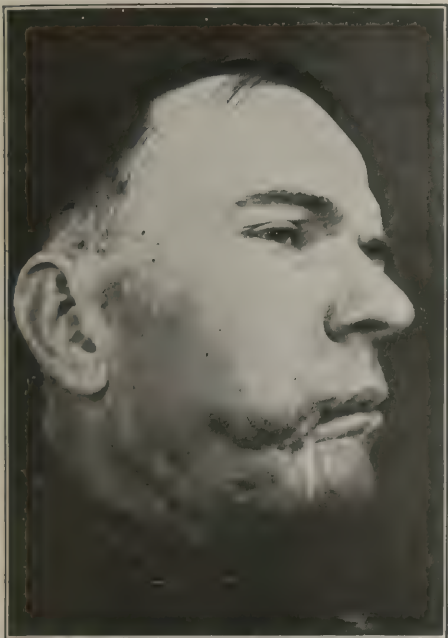

FIG. 248.—Lateral view before operation.

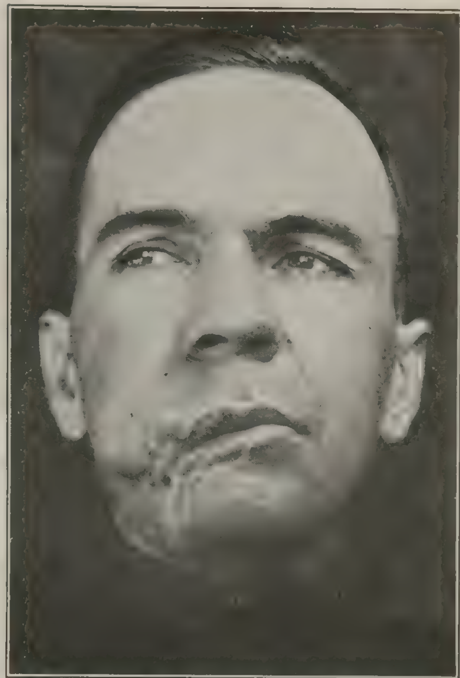

FIG. 249. Front view before operation.

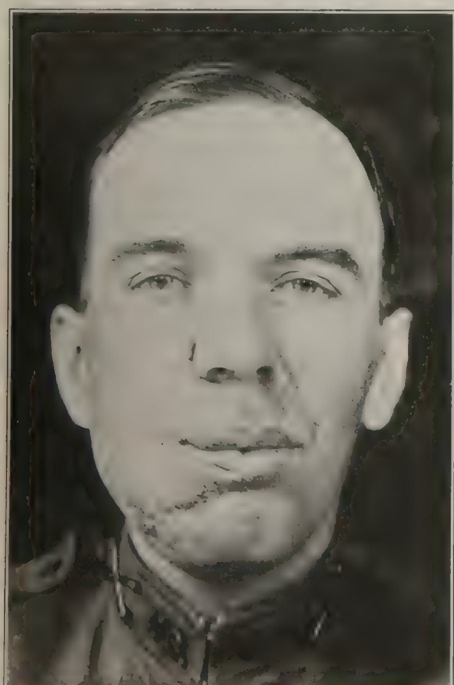

FIG. 250.—Completed case.

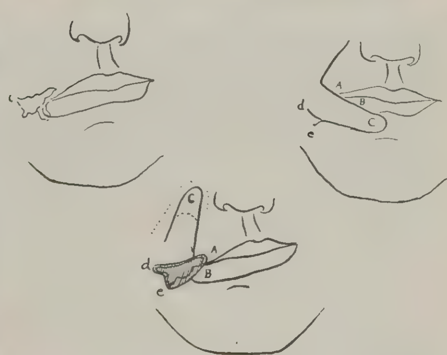

FIG. 251.—Drawings illustrating repair of case shown in Figs. 248, 249, and 250 by descending nasolabial flap.

excision that the least possible amount of good skin would be sacrificed. These pictures illustrate such a procedure. Before attempting to draw together the borders of the wound the surrounding tissues were undermined as far as the dotted line so that they could be approximated without tension. In this situation the undermining was made just superficial to the periosteum.

Figure 255 shows the result of a deep oblique cut made by a shell that destroyed the eye and lower eyelid and allowed the cheek and corner of the

mouth to slump down. The injury did not involve the bone. Figure 256 shows the plan of repair. At the first operation the scar area was excised (indicated by oblique shading) and the tissues undermined to the extent indicated by the dotted line. Above and external to the excised scar the plane of undermining was made superficial to the buccal and temporal fasciæ, while below and in front of it the soft tissues were raised from the bone. The lower flap was made to overlap the exposed buccal and temporal fasciæ and was sutured in place. This filled the defect and raised the cheek and corner of the mouth. Figure 257 shows the result of the first operation. At a subsequent operation, after separating the mucosa from the skin surrounding the lower eyelid defect a temporal flap was switched in to replace this eyelid (Fig. 258). The line of dots across the cheek shows spots of pressure atrophy due to the buttons holding deep tension sutures. Figure 259 is a photograph of the completed case.

Figures 260 and 261 show shell wounds through the full thickness of the cheek and body of the mandible, which has partially healed with the cheek tissues slumped downward. A relatively small sharp-edged piece of shell spinning around like a circular saw would cut a very deep and wide gash in the tissues. Figure 262 is a diagram illustrating scheme of correction. The upper left-hand drawing represents the condition on return from overseas. The shading in the middle figure shows the plan of scar excision which went completely through the cheek into the mouth. The dotted line shows the extent of the deep undermining which was just superficial to the bone, while there was a less extensive plane of undermining done between the skin and muscle. Note the conservative manner in which the scar excision was done and how the external canthus as well as the whole cheek was raised by the suturing. In suturing, the buccal mucosa was approximated with tannated gut and the intermediate tissues were overlapped with plain gut for the double purpose of elevating the cheek and corner of the mouth and of filling out the thickness of the cheek. This latter line of sutures was reinforced by deep mattress silkworm gut stay sutures, which were tied over rubber tubing or buttons on each side of the wound. The skin was closed with interrupted horsehair. The depth of the wound was freely drained with rubber dam strips both on the buccal and external surfaces. This was an important step. Such wounds are always soiled and have irregular spaces in their depths that can not be immediately obliterated to advantage. It was observed that the blood clot can play only a sinister roll in plastic surgery. The lower left-hand drawing shows the preliminary ligation of the external carotid artery as a means of limiting hemorrhage. A temporary control of the opposite common or external carotid is usually of further advantage. In the evacuation hospitals it was a notable fact that wounded soldiers bled very little at the first operation, and even with large débridements few ligatures were necessary. At later operations, however, the conditions were reversed and the hemorrhage from excision of scars became so excessive as often to threaten life if very careful preventive measures were not employed. The mere use of hemostatic forceps was not sufficient, as in many of these cases forceps could not be placed sufficiently close together to control all the bleeding points. The radiogram in Figure 263 shows the defect in the body of the lower jaw corresponding to the cheek cut. Note that the ramus is drawn forward, which has lessened the apparent extent of the defect. The sliding pedicle graft was taken

Fig. 252.—Broad depressed scar of forehead.

Fig. 253.—Same case after repair by operation shown in diagram (Fig. 254).

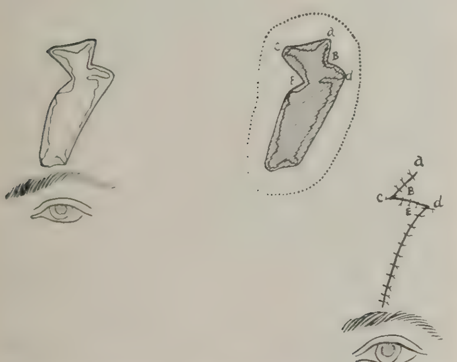

Fig. 254.—Diagrams illustrating repair of case shown in Figs. 252 and 253.

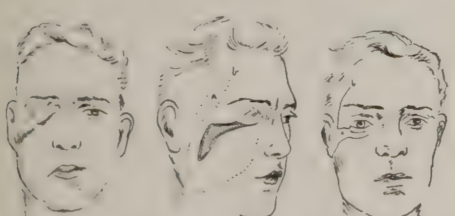

Fig. 256.—Diagrams showing plan of repair of case shown in Fig. 255.

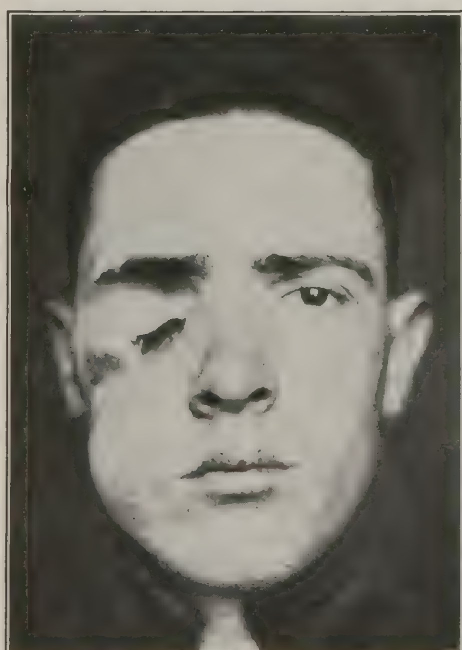

Fig. 255.—Result of deep oblique cut made by shell, allowing cheek and corner of mouth to slump down.

Fig. 257. Result of first operation (Figs. 255–256).

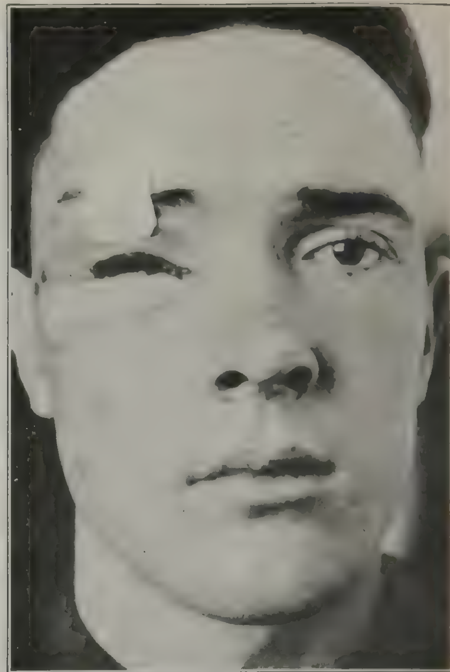

Fig. 258.—Result of temporal flap to replace lowe eyelid.

Fig. 259.—Completed case.

Fig. 260.—Slumping downward of tissues of cheek following full thickness shell wound.

from the lower border of the mandible and fastened in place with wires which were left protruding through the surface wound to provide drainage (Fig. 264). A supplementary drain was placed in the most dependent part of the wound not in contact with the bone. The mouth was accidentally opened during the procedure. This, however, was a routine precaution against the blood clot which some operators actually courted. The radiogram in Figure 265 shows the bone graft grown solid. During the healing process both

FIG. 261.—Lateral view of same case (Fig. 260).

FIG. 262.—Diagrams illustrating scheme of correction.

FIG. 263.—Radiogram showing defect in body of lower jaw corresponding to cheek cut.

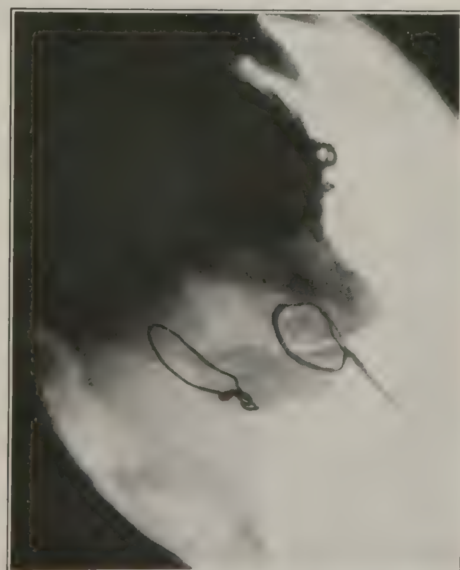

FIG. 264.—Radiogram showing sliding pedicle graft from mandible to fill defect.

jaws were fixed by a splint. Figures 266, 267, 268, and 269 are profile and full front views of the case showing condition at the time of operation and at discharge from the hospital. Note that the external canthus, the corner of the mouth and the cheek have all been elevated.

Fig. 265.—Radiogram showing solidification of bone graft.

Fig. 266.—Profile view of same case (Fig. 260), showing condition before operation.

Fig. 267.—Profile view of case on discharge from hospital.

Fig. 268.—Full front view of case, showing condition before operation.

Figure 270 is a drawing of a case in which most of the injury was confined to the inside of the mouth, destroying the lining of the right cheek, a section of the body of the mandible, and some of the full thickness of the cheek near the angle of the mouth. The malar bone was fractured and pushed outward, which resulted in cheek bone and zygoma being more prominent. The first step in the operative treatment was to restore the lining of the cheek and also the skin about the corner of the mouth. This was done by removing all of the scar and then, from the neck and chest, cutting a long flap which was drawn into the mouth through an incision in the lower buccal fornix; the tip of the flap was drawn out

FIG. 270.—Diagrams showing restoration of destroye lining of cheek by flap of skin from neck.

FIG. 269.—Full front view of patient (Figs. 260–268) on discharge from hospital.

FIG. 271.—Same case as illustrated in Fig. 270, showing condition immediately after suture of long flap in place.

FIG. 272.—Showing long neck flap forming lining to cheek.

through the oral fissure and sutured into the external cheek defect, as shown in the central drawing. Twelve days later the pedicle was cut and the base of the flap returned to the neck. The figure to the left shows the amount of the flap that was left in the cheek. Figure 271 shows the condition immediately after the long flap was sutured in place. The defect resulting from removing the flap from the neck and chest was obliterated by undermining and drawing the edges together. The lower end of this sutured wound, the depth of each pocket in the neck resulting from the undermining, and the potential pocket resulting from the twist, made where the flap turns on itself to enter the mouth and the space between the flap and the cheek, were all drained by rubber dam drains which were sutured in place. The last two of these drains were of particular importance in cases in which the parotid gland was still active. In many the gland seemed to have been destroyed by obstruction of the parotid duct by scar tissue. Figure 272 shows a later condition when the flap had healed in place and was forming the lining of the cheek. Skin so turned into the mouth usually

Fig. 273.—Radiogram showing bone defect in same case (Figs. 270–272).

Fig. 274.—Radiogram showing repair of bone defect following sliding bone graft, same case.

behaved very well, becoming pink in color and rather closely resembling mucous membrane. Occasionally, when redundant, it rose into folds formed by the scar base and required partial excision. If it was hair-bearing the hair continued to grow and required trimming until it was destroyed by radium. The radiograms in Figures 273 and 274 show the repair of the bone defect which was closed partly by a sliding bone graft made from the lower end of the ramus and partly by an outgrowth of new bone which was formed as the two ends of the bone were slowly separated by a traction splint. This gradual separation of the ends restored the jaw to its normal occlusion, the potential gap being filled with new bone which formed concurrently with the separation of the fragments. The radiogram shows also the gap in the ramus where the subcutaneous saw cut was made and the bar of new bone that helps to bridge the gap.

The photograph in Figure 275 shows the soft parts repaired, but the abnormal width of the right side in the malar region still persists. To determine the exact amount of this increase, a plaster cast was made of each side

of the face and the left cast was built up with clay until it was of the same prominence as the right (Fig. 276). The piece of cast built on clay was then cut through to determine its depth. This depth showed the amount that had to be removed from the right cheek bone to make it correspond to the left, the normal side. Figure 277 shows distortion of cheek and mouth, original condition. The patient at this time had the posterior part of the body of the right mandible drawn forcibly against the palate. Figure 278 shows the condition when the patient was discharged from the Army. The jaw bone was solid and he could open his mouth freely. Figures 279 and 280 show the lateral aspect taken at times corresponding to Figures 277 and 278.

Figure 281 illustrates a case in which a large opening in the anterior part of the palate, caused by a piece of shell, was repaired with a skin-covered

Fig. 275.—Same case as in Figs. 270–274, showing soft parts repaired, but persisting abnormal width of right side in malar region.

Fig. 276.—Plaster cast built up with clay on left side to make two sides symmetrical.

pedicle flap taken from the front of the chest. The upper left hand figure shows schematically the flap outlined; the upper central figure, the opening in the palate; the lower central figure, the flap turned into the mouth through an opening in the inferior buccal fornix with a relaxation incision posterior to the defect in the neck. The figure to the right shows the flap sutured into the palate defect and the neck defect closed by drawing its borders together. The next step was to cut the pedicle of the palate flap at the palate border, to freshen its granulating surface, and, after reopening the upper part of the healed neck wound, to suture the pedicle back into the neck, as shown in Figure 270. The relaxation incision would close of itself. Later these rather rough scars could be excised and more exact approximation made by careful suture. The scars could be further improved by the use of radium, but a vertical scar in the neck is always visible. Figures 282, 283, and 284 are from photographs of the condition in various stages. In Figure 284 as yet no attempt

Fig. 277.—Distortion of cheek and mouth, case shown in Figs. 270–276.

Fig. 278.—Condition of case shown in Fig. 277 at time of discharge.

Fig. 279.—Lateral aspect of case shown in Fig. 277.

Fig. 280.—Lateral aspect of case at time of discharge.

had been made to improve the neck scar and the flattening of the upper lip was due to lack of teeth, later corrected by a denture. As shown in Figure 283, the patch in the palate formed a rather prominent pad, which later, with the use of a dental plate, was flattened to conform to the general contour of the palate.

Figure 285 is a diagrammatic illustration of the correction after the lower lip and most of the covering of the chin had been torn away by a piece of shell.

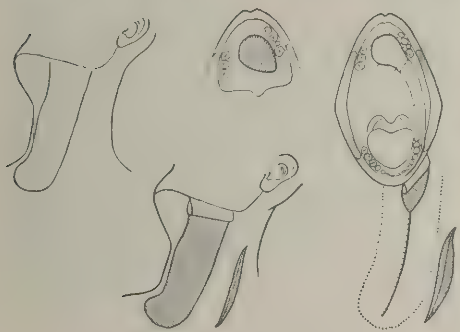

Fig. 281.—Diagrams illustrating repair of large palatal defect with skin flap from neck.

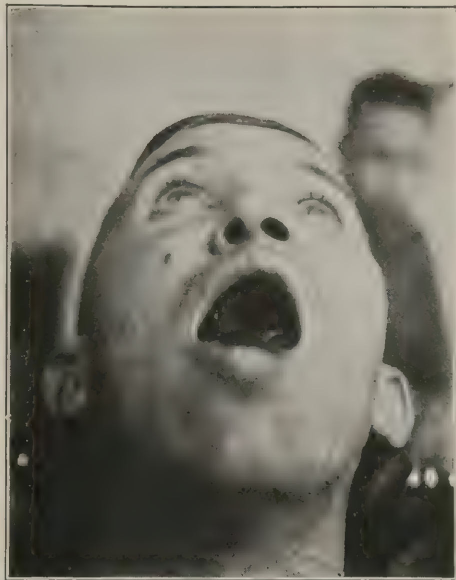

Fig. 282.—Original defect in palate.

Fig. 283.—Defect closed with neck flap.

Fig. 284.—Appearance of profile and neck before correction by denture and removal of scars.

Scar contraction had drawn the neck tissue up over the mandible till much of the original defect had become covered, as shown in the right upper illustration. The excision of the scar left the defect shown in the left upper figure.

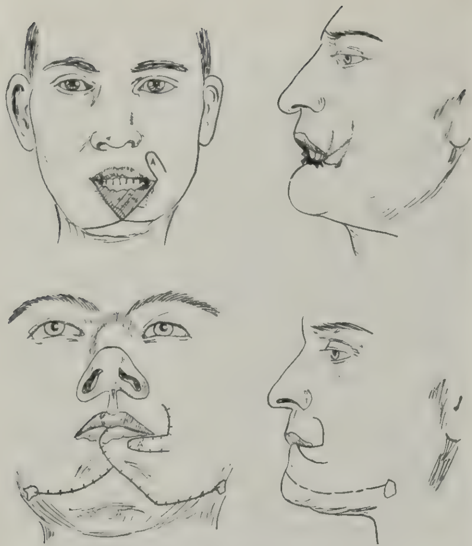

FIG. 285.—Diagrams illustrating restoration of lower lip and covering of chin lost as a result of shell wound.

FIG. 287.—Condition after large cheek flaps were brought down.

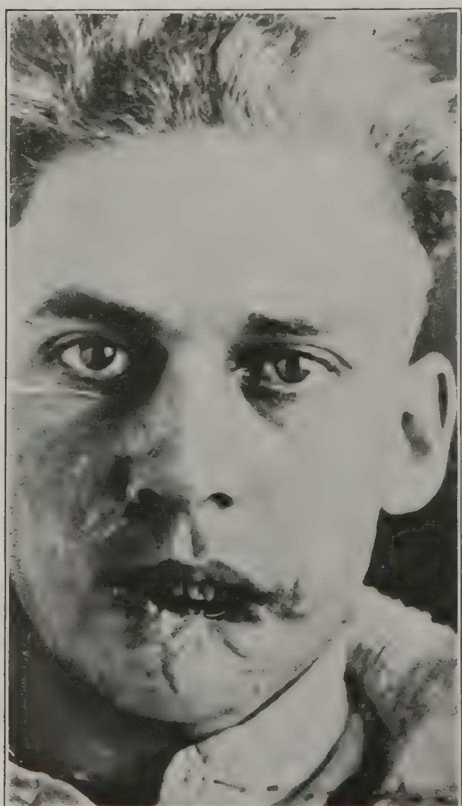

FIG. 286.—Showing condition when case reached reconstruction hospital in United States.

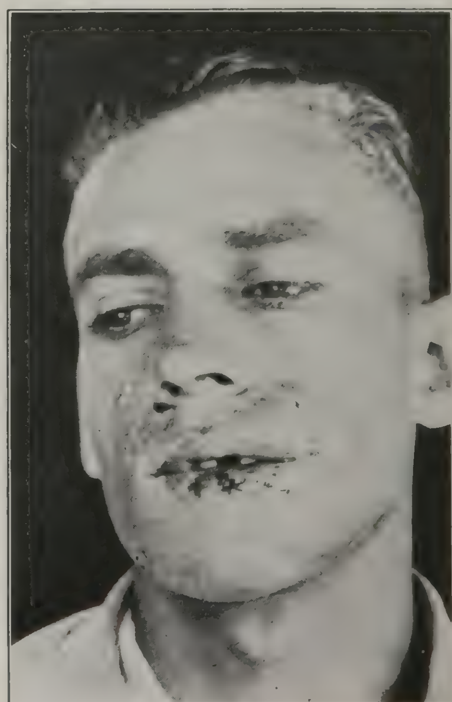

FIG. 288.—Completed case.

From the lower point of the V on each side an incision was made to the bone, downward and outward, to the lower border of the mandible, and then back to the anterior border of the masseter muscles, the flaps being dissected entirely free from the periosteum. A corresponding incision was made through the mucosa along the inferior buccal fornix. At the posterior extremity, this horizontal incision in the mucosa turned sharply upward to end just beneath the opening of the parotid duct. This vertical part of the intraoral incision went through not only the mucosa but the buccinator muscle and buccal fascia. The anterior part of each of the two cheek flaps thus mobilized was rotated upward until the edges that formed the lateral borders of the V were made to form the free border of the lower lip. By the incision described and some undermining in the submucous tissue, the buccal mucosa had been sufficiently freed to permit of its being drawn over the raw surfaces on the border of the new lip and sutured to the skin, thus making a vermilion border. Suturing these flaps to the tissue on the point of the chin which had become fixed there by scar tissue served in turn to fix them in their new position. Originally there had been some loss of tissue in the left cheek below and external to the corner of the mouth. Including this last-mentioned scar in the excision made the left arm of the V longer than the right, which accounts for the fact that more of the lower lip was formed from the left flap than from the right. With this, however, there was a corresponding deficiency in the vertical extent of the left half of the lip near the corner (Fig. 287), which was compensated for by the flap "A" taken from the junction of the cheek with the upper lip. The lower left figure shows the flaps sutured in place. The artist used some poetic license in portraying the outline of the vermilion border. The lower right figure is a good representation of the lateral aspect of the case when finished. Figure 286 shows the condition when the patient reached a hospital in this country. The condition after large cheek flaps were brought into place, but before the small upper "A" flap was turned down, is shown in Figure 287; Figure 288 pictures the completed case.

MISCELLANEOUS CASES.

Figures 289–301, inclusive, show the various stages of repair in a case in which a shell passed through both cheeks, splintering the body of the mandible on both sides and tearing a large hole of exit on the right side. Owing to the press of war conditions, neither proper fixation nor drainage was established at the time of the injury, and this, added to lack of special care in subsequent evacuations, permitted of extensive necrosis of the bone and loss of all teeth in the remaining chin fragment. When the patient arrived at a reconstruction hospital, 10 months after injury, there was loss of the body of the mandible from the second molar to the canine tooth on the left side and the lower half of the ramus and the body as far forward as the canine tooth on the right. There was union on neither side and no teeth in the chin fragment. The teeth in the upper jaw were good. An aluminum splint was constructed to embrace all of the upper teeth and the palate, and having a protruding bar which extended forward to a distance of 3 inches in front of the incisor teeth. On the left side the ramus was subcutaneously cut in two transversely by a wire saw and the ends of the body bordering the defect on that side were freshened

and wired together, after the newly constructed jaw was pried and dragged forward. Two heavy wires were passed around the mental fragment and fastened to the end of the bar on the splint, or rather to a downward extension of this bar which brought the line of traction into the plane of the body of the mandible.

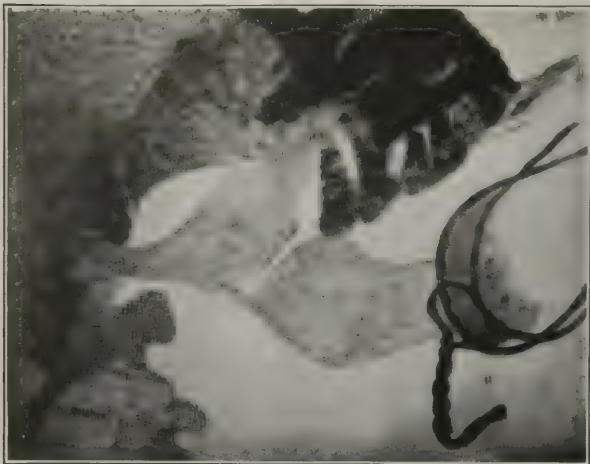

Fig. 289.—Diagrammatic reproduction of radiogram showing cut in ramus and circumferential wires to draw symphysis fragment forward.

Figure 289 shows (1) the cut in the ramus; (2) the posterior body fragment including the angle dragged forward; (3) the wire uniting the two fragments with its twisted ends protruding for drainage; (4) the two circumferential traction wires passing about the mental fragment. Figure 290 shows an external view of the splint and wires and the scar due to loss of tissue on the right side of the face.

Fig. 290.—Shows scar due to loss of tissue on right side of face and splint to which circumferential wires were attached.

Fig. 291.—External traction by cord and weight.

The strain on the splint was so great that it caused pain and threatened the anchorage of the upper teeth. To relieve this the patient was put to bed and a counter weight was applied to a cord which was attached to a bar of the

splint and passed over a pulley block in the ceiling, as shown in Figure 291. After a week or 10 days this weight extension was dispensed with. The next operative step was the excision of the scar and the transfer of a flap from the side of the neck to the cheek, as shown in Figure 292. An attempt was made

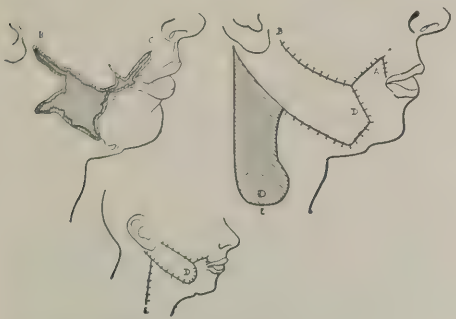

FIG. 292.—Diagrams illustrating excision of cheek scar and repair by neck flap.

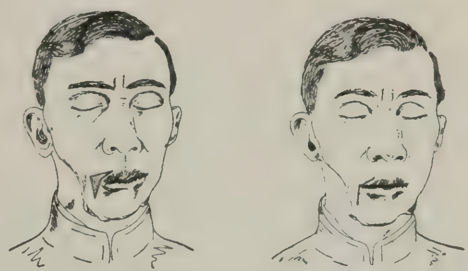

FIG. 293.—Diagrams illustrating operation to correct right corner of mouth.

to plant a piece of rib in the site from which this flap was to be obtained, but, owing probably to an injury of the parotid gland, there was necrosis of tissue and the rib had to be removed and the transfer of the flap delayed.

FIG. 294.—Front view showing results of treatment illustrated in Figs. 289–293.

FIG. 295.—Side view of case at this stage.

Figure 293 shows a plastic operation which was done to correct the sphincter-like appearance of the right corner of the mouth. The shaded area in the left-hand figure was excised through the full thickness of the cheek and the wound closed, as shown in the right-hand figure. Figures 294 and 295 show the results obtained by the operations thus far described.

Following the plastic operation on the right cheek, a Gillies bone-cartilage graft was placed in the defect in the right side of the mandible. One-half inch of the tip of the left ninth rib and almost all of the cartilage, which makes a sharp angle, were removed, and the rib part was united to the freshened left end of the mental fragment while the sternal end of the cartilage was buried in a tunnel burrowed between the soft tissues and the external surface of the remaining part of the ramus. This operation had to be performed in two steps. After preparing the bed to receive the graft, in order to avoid using the great number of ligatures that would be needed to partially control the bleeding, the wound was closed with 24-hour drainage; about a week later it was reopened and the graft inserted.

Fig. 296.—Radiogram showing cartilage-bone graft replacing right body of mandible.

Fig. 297.—Left body of mandible showing bone regeneration.

Figure 296 shows the cartilage-bone graft replacing the right body of the mandible. The cartilage is visible in the radiogram because of lime deposits. When first seen it was thought that this might be due to the change of function, but an X-ray examination of the chest showed all cartilages similarly affected. Comparing Figure 297 with Figure 289, there seems at first glance to have been an apparent lengthening of the reconstructed body. Careful comparison leads to the conclusion that this is an actual lengthening due to the ramus, which was dragged forward at the time of operation, gradually retreating to its normal position with a concurrent deposit of bone at the site of union, the mental fragment being fixed at the time by the splint. The radiogram shows that the mental fragment had not materially changed its position. Such a deposit of bone at the site of a mandibular fracture, when the fragments were gradually drawn apart by a traction splint, was frequently observed, and quite large gaps were made to fill in by this procedure.

Figures 298 and 299 are front views of this patient at the time of entering the reconstruction hospital and when last seen.

Figures 300 and 301 are profile views of same patient. The scars resulting from the plastic operations have been excised and resutured. An inlay graft (Waldron type) was used to deepen the inferior dentolabial fornix. The chin has been rounded out with a deep injection of cold paraffin because the patient wished to avoid another such serious operation as a cartilage graft. (See Fig. 312.) In spite of the prevalent and wise prejudice against the use of paraffin, it is probable that the injection of cold paraffin in a solid mass is free from the serious objections that have been raised against the infiltration of the tissues with the melted wax.

Figure 302 shows a man in whom the right two-thirds of the upper lip, the lower half of the right cheek, the greater part of the lower lip and chin, and all

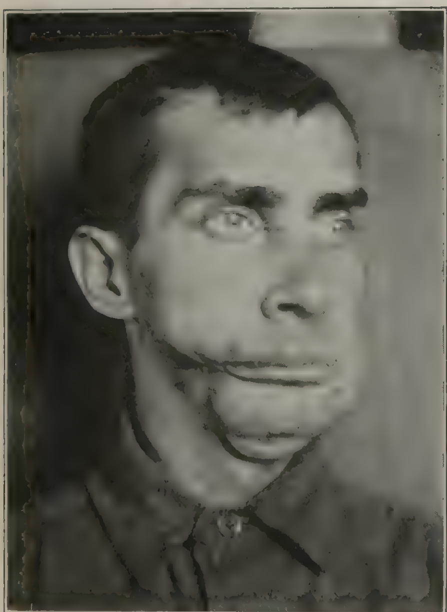

FIG. 298.—Front view of this patient at time of entering reconstruction hospital.

FIG. 299.—Front view of patient when last seen.

of the mandible in front of the second molar tooth were destroyed by a shell fragment. The first step in the reconstruction was to cut the ramus in two, transversely on each side, and to slide the remaining part of the body and angle of each side as far forward as possible, where they were retained by a specially prepared contrivance. In this way about seven-eighths of an inch in the length of the body of the jaw was gained on each side. This procedure is shown in Figure 289. The second step (Fig. 303) was to reconstruct the upper lip by cutting the flaps "A" and "B" through the full thickness of the cheek and, after freeing the distorted floor of the right nostril, to rotate these two flaps downward and suture them in place, forming the upper lip.

To obtain material for the lower lip and chin, including the mental part of the mandible, the flap outlined in Figure 304, which included the head and 3 inches of the full thickness of the clavicle, was raised and sutured back in

its bed (delayed transplantation). This was done under novocain. A subsequent bronchitis precluded transferring this flap and several months elapsed before the flap was again raised and again resutured in its bed, preparatory to transfer. This time the tip of the flap became gangrenous, as shown in Figure 305. Ten days later the skin covering the chin area and the lower lip was split vertically in the mid line and a transverse incision was made on the chin surface below. (Right-hand picture, Fig. 306.) The resulting flaps were dissected laterally, exposing the free ends of the mandible on each side. That on the left was shorter than the one on the right, but in twisting the pedicle to throw the skin surface forward the head of the clavicle was brought in contact with the end of the shorter left mandible, which compensated for its shortness and allowed the graft to lie transversely. The chin and the right two-thirds of the lower lip, external and internal surfaces, were reproduced in this way, and by suturing

FIG. 300.—Profile view of same patient at time of entering reconstruction hospital.

FIG. 301.—Profile view of patient when last seen.

the intraoral skin to the freed sublingual mucosa the upper surface of the graft was entirely covered.

Figure 306 shows the manner in which the flap was transferred. Sometime before the clavicle flap was placed in the chin a slight plastic operation was done on the lower lip to help prevent the dribbling of saliva, which, in these cases, was very annoying. The plan of this operation is shown in the two central sketches, Figure 306. Figures 307 and 308 show the result of the placing of the chest-clavicle flap in the chin after the pedicle had been cut and returned to the neck. It looked like a big flap when it was made, but if it had been twice as broad the result would have been very much better.

Figures 309 and 310 give a front view of the condition on arrival at the reconstruction hospital, and of the final condition after the point of the chin had been rounded out with a cartilage graft and some adjustments of the lower lip had been made.

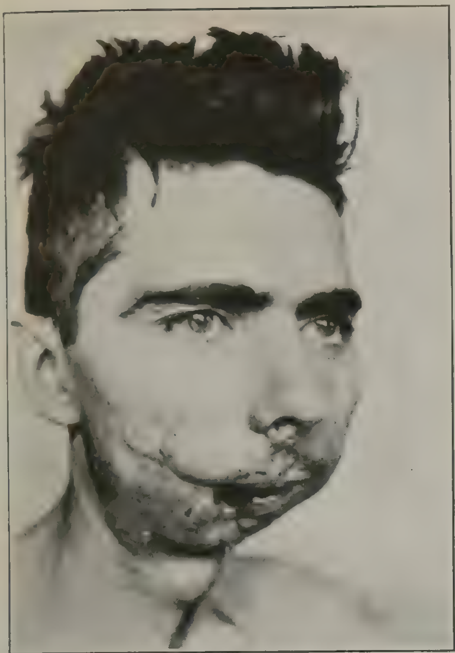

Fig. 302.—Destruction by shell of part of upper lip, right cheek, most of lower lip and chin, and all of mandible in front of second molar tooth.

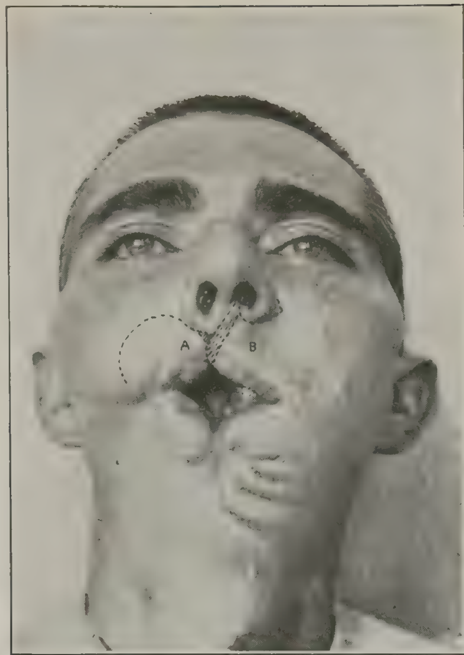

Fig. 303.—Reconstruction of upper lip by flaps, outlined.

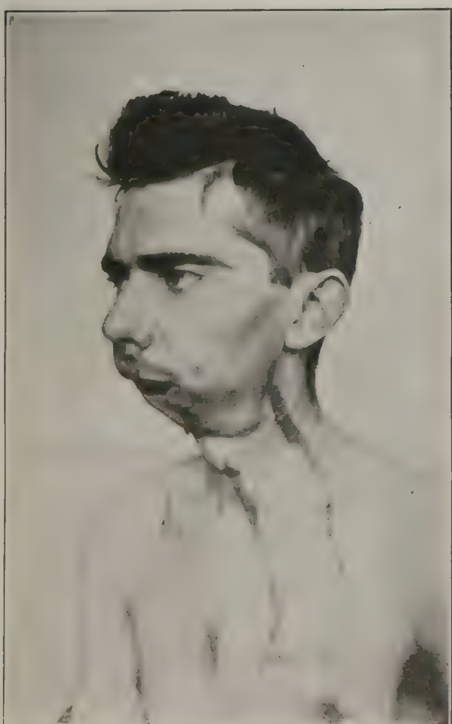

Fig. 304.—Showing outline of neck flap including clavicle.

Fig. 305.—Neck-clavicle flap raised and sutured back in its bed preliminary to delayed transplantation.

Figure 311 is a view of the original deformity. Figure 312 shows side view of the case after cartilage transplant was made. The distance from the columella to the tip of the chin was greater than called for in the ordinary formula for good facial balance, but this helped to neutralize the very prominent nose. The full extent of the original deformity can not be appreciated from Figure 311 because it is not a true profile. Later, after the labio-alveolar fornix was reconstructed with a skin graft the patient was fitted with a denture. Figure 313 is a radiogram of the clavicle graft in place, bony union having occurred and the wires not having been removed. It may be noted that on the right side the graft was a bit short and had only a slight contact with the jawbone, but that a growth of bone had bridged the space. On the left side, because the remaining part of the body of the jaw was shorter than the right, the edge of the

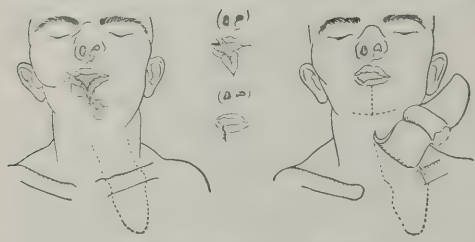

FIG. 306.—Diagrams illustrating delayed transfer of neck-clavicle flap to repair defect in chin and mandible.

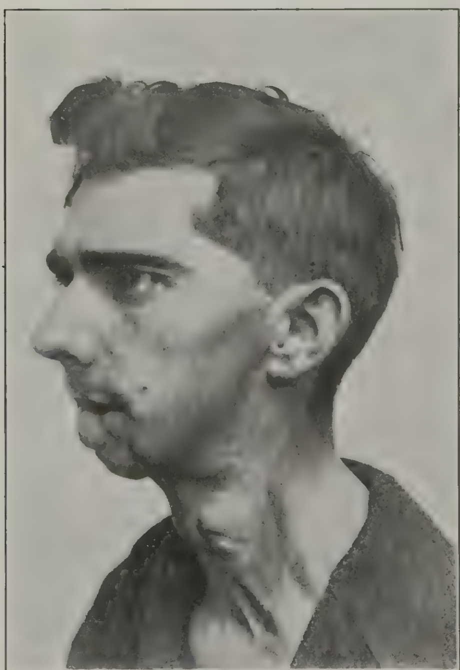

FIG. 307.—Profile view after placing chest-clavicle flap in chin.

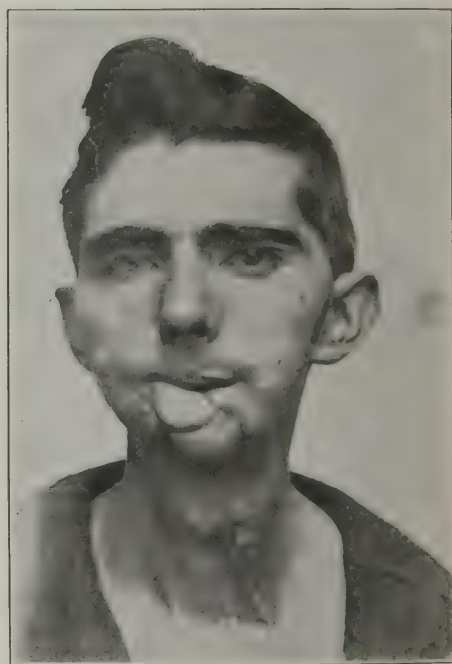

FIG. 308.—Full face view of same stage as shown in Fig. 307.

head of the clavicle was placed against the end of the body of the jaw so as to throw the graft as far forward as possible. The prominent border of the head of the clavicle has been absorbed all round, except where in contact with the jaw, and here the contact has been strengthened by a deposit of bone. This is but another illustration of the truth and force of Lane's definition of bone, "ossification in the lines of force."

FIG. 309.—Front view of condition on arrival at reconstruction hospital.

FIG. 310.—Final condition after point of chin had been rounded out with cartilage graft.

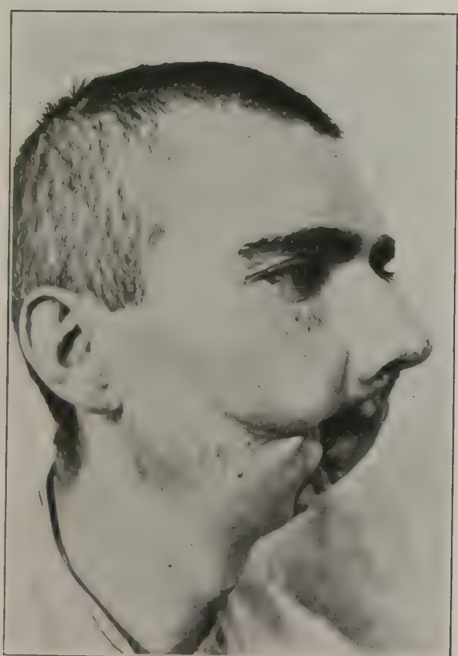

FIG. 311.—Profile view of original deformity.

FIG. 312.—Side view of case after cartilage transplant was inserted.

An injury of which there were relatively few instances during the war was the clipping out of the root of the nose (Figs. 314 and 315) and, unfortunately, usually associated with the loss of one or both eyes. In the case to be described, though both eyeballs were gone the lids were undamaged. The correction consisted in first cutting out all scar, which allowed the tissues to be retracted, reproducing the original defect, and then turning a flap from the forehead and suturing it in such a way as to preserve the contour of the bridge.

Figures 316 and 317 show the result of operation in this case. If the defect to be bridged in such a case was very large, an osteoplastic flap was made of the

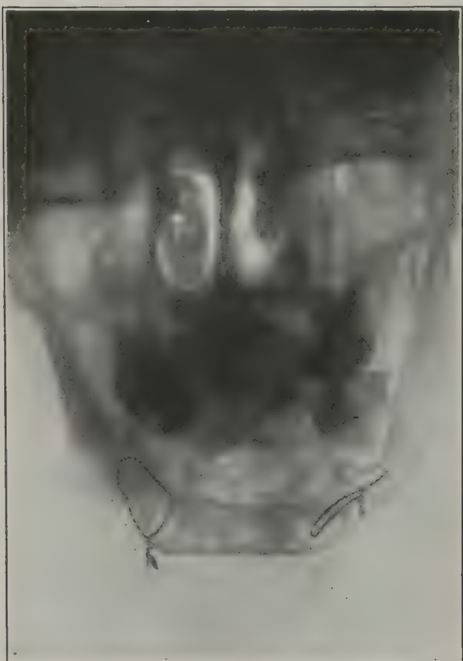

FIG. 313.—Radiogram of clavicle graft in place (Figs. 302–313).

FIG. 314.—Loss of root of nose and both eyes.

periosteum and a strip of bone covering the frontal sinus; this was turned down on a hinge of periosteum and muscle, so that what was the outer surface of the upper end of the strip of bone came to rest on the upper end of what remained of the bridge of the nose. In one case so treated pus was found in the opened frontal sinus; permanent drainage was established and the operation continued. After the bridge of bone was in place a flap of skin was turned down to cover it. This flap could be made, at the same time, to repair an eyelid.

Figure 318 shows a case in which the nasal injury was combined with an injury of the upper eyelid. The central figure shows the forehead flap turned

Fig. 315.—Profile view showing loss of root of nose.

Fig. 316.—Front view showing result of operation.

Fig. 317.—Profile view showing result of operation.

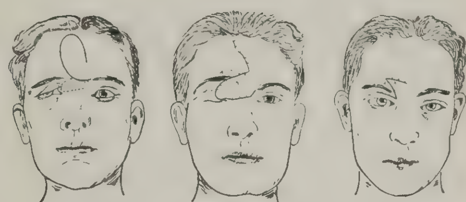

Fig. 318.—Diagrams showing repair of defect of root of nose combined with injury of upper eyelid.

into place and the forehead defect converted into a linear wound. In placing this flap the inner end of the right eyelid was forced to an abnormally high position. The right-hand figure shows the subsequent correction of this by making a Z incision and switching the flaps.

Figures 319 to 323 are photographs of the case illustrated in Figure 318, showing the condition when the patient came to the reconstruction hospital and upon his discharge.

Fig. 319.—Profile view of case illustrated in Fig. 318 before operation.

Fig. 320.—Front view of same case before operation.

Fig. 321.—Front view of same case shortly after bringing down forehead flap.

Fig. 322.—Profile view after operation.

Figure 324 shows drawings of a case following an open fracture of the nose with considerable laceration of the soft parts. The bone bridge was depressed and displaced laterally. The upper left-hand picture gives the lateral view, while that to the right is a front view, with the flaps for correction outlined on the surface. The "A" flap included the full thickness of the nasal bones and was raised from its bed with a chisel and fractured across its base. The "B" flap was of the soft tissues only. After the "B" flap was raised the tip of the "A" flap was brought to the left so that it rested upon the lower boundary of the notch, while the "B" flap was switched to the right to take the place of the "A" flap, as shown in the lower right-hand figure.

Figures 325 and 326 are photographs of case before operation.

Fig. 323.—Front view after operation (Figs. 318–322).

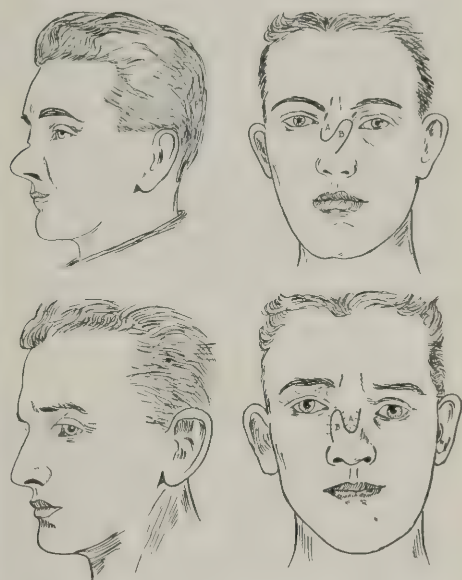

Fig. 324.—Drawings illustrating repair of depression and lateral displacement of bridge of nose.

Figures 327 to 329 show the result of the operation. They also show a downward displacement of the inner canthus only partially corrected at this time. Correction of the downward depression of the inner canthus in these cases where the scars went through the nasal and lacrymal bones consisted in the removal of the lacrymal sac and cutting a tongue-shaped flap from the upper eyelid, base on the root of the nose, and switching it into an incision made transversely just below the canthus after the canthus had been moved up to its proper position.

FIG. 325.—Profile view before operation.

FIG. 326.—Front view before operation.

FIG. 327.—Front view showing result of operation.

FIG. 328.—Lateral view showing result of operation.

Figure 330 shows drawings of the right side of a face that was very much damaged by shell. The damage to the nose is shown in this and in subsequent figures, but the depression and loss of bone below the right eye socket does not show. The shaded areas in the upper left figure represent the scar excision. The undermining beneath "E" was just beneath the skin, while that under "A" and "D" was just superficial to the periosteum. After the flap "A," consisting of skin and superficial fascia, had been raised from its bed (lower left figure), the deep surface of the subadjacent deep tissues was superimposed on the subcutaneous tissue under "E," as shown in the upper central figure, thus, partially filling the hollow below the socket, approximating "D" to "E," and raising the right corner of the mouth. Then the skin flaps "E" and "D" were sutured and the "A" flap placed between "C" and "B," as shown in lower right figure. Later the flattened nasal bones were chiseled free from the nasal processes of the maxillæ, pried forward, and held there by a dental splint, as shown in the upper right figure. The right-hand figure shows the splint in place anchored to the teeth. The one to the right also shows the left ala to be entirely missing and a deep scar on the cheek.

Fig. 329.—Final result (Figs. 324–328).

Figure 331 illustrates how the material for the left ala was obtained. The scar in the left cheek was excised. The flaps "A" and "B" were outlined, "B" was raised and sutured, raw surface out, into the defect in the left side of the nose after the scar was removed. It was then covered by the "A" flap, as shown in the lower left-hand figure. Later the "A" pedicle was cut and the unused parts returned to the forehead. This produced the condition shown in Figure 332. The thickness of the ala was reduced by subcutaneous

Fig. 330.—Drawings showing correction of deformity of nose and cheek.

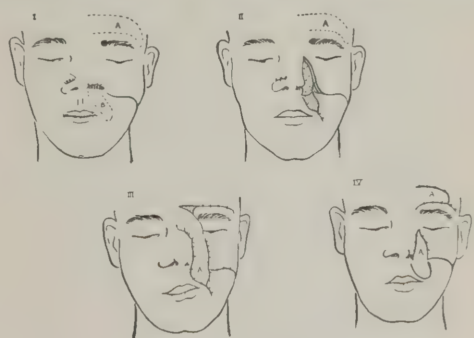

Fig. 331.—Drawings illustrating reconstruction of left ala.

excisions, and by operations shown in Figure 333 the crease between the ala and cheek was reproduced. It was further deepened by lining the depth of excision with a Thiersch graft. The part of this deformity that was dependent upon the depression of the lower lid was corrected by switching a flap from the temple into the cheek just below the lid and also by implanting a piece of costal cartilage into the defect in the lower border of the orbit. A piece of cartilage was also implanted into the nose. (See drawings, Fig. 334 and Figs. 335 and 336, for stages in the progress of the case.)

FIG. 332.—Intermediate stage in repair of left ala.

Figures 337–340 show the front and profile view as they were on entering the hospital and as they appeared near the completion of the case. The stare that remains about the right eye is due to poor action of the upper lid dependent on a badly fitting artificial eye. The relation of the margin of the lower lid to the iris is about the same in each eye. The full extent of the original deformity can not be gauged from Figure 339, because it is not a true profile. On the other hand, the artist, by the skillful use of lights, entirely eliminated the cheek scar which, though not depressed, still shows on the man (Fig. 340).

Figures 341 and 342 show two somewhat early views of a soldier who had extensive destruction of the nose and left maxilla, with a downward slump of the left lip, cheek, palpebral fissure, and eyeball.

Figure 343 shows a later stage with a cartilage implanted under the soft tissues of the forehead for the purpose of making the nasal bridge. This cartilage, however, was not used, and was later removed. The first steps of the final plan of reconstruction are shown in Figure 344. On a plaster cast of the patient a clay nose was modeled. From this clay nose a tinfoil pattern was made, which later was used to outline the flap on the forehead and its plan of implantation laid out.

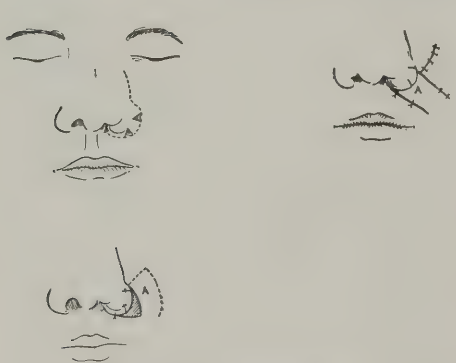

FIG. 333.—Diagrams illustrating completion of left ala.

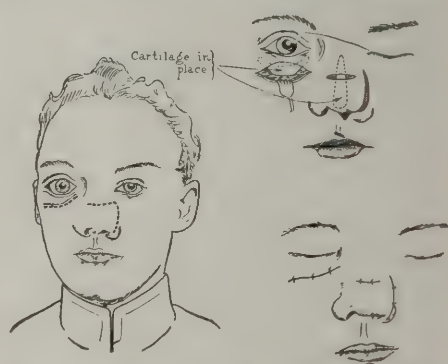

FIG. 334.—Diagrams illustrating cartilage implantations into nose and right cheek.

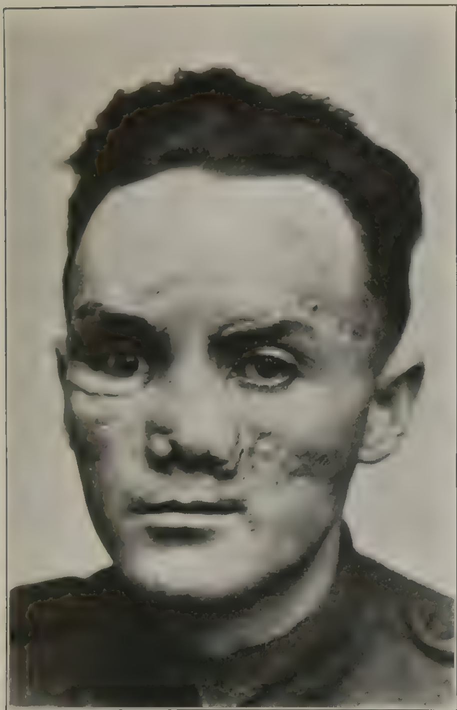

FIG. 335.—Intermediate stage in progress of case (Figs. 330–334), front view.

FIG. 336.—Intermediate stage in progress of same case, profile.

FIG. 337.—Front view of same case on entering hospital.

FIG. 338.—Front view of same case near completion.

FIG. 339.—Profile view on entering hospital (Figs. 330–338).

FIG. 340.—Profile view of same case near completion.

FIG. 341.—Early view of extensive destruction of nose and left maxilla.

FIG. 342.—Same case showing early splinting.

FIG. 343.—Later view (Figs. 341, 342) showing opening into nose and cartilage implanted beneath skin of forehead.

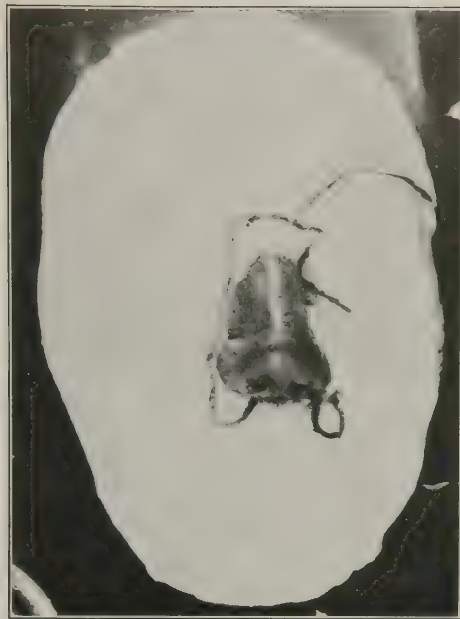

FIG. 344.—Clay nose built up on plaster cast of face, to be used as pattern for subsequent surgical reconstruction.

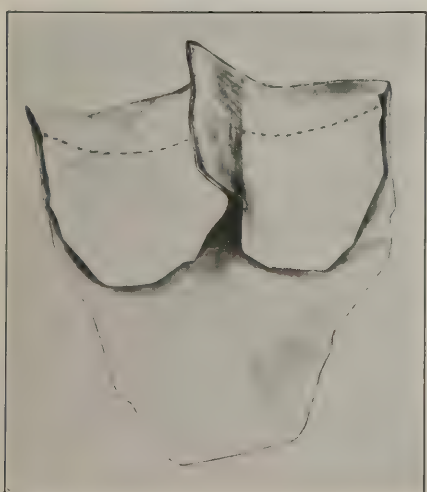

FIG. 345.—Drawing of tinfoil pattern of flap to reconstruct nose.

FIG. 346.—Appearance shortly after turning flap down from forehead.

Figure 345 is a drawing of the tinfoil pattern of the flap folded in the manner in which it was used (one is supposed to be looking at the inner surface). The double fold in the center is the future columella and septum, while the surfaces on either side of this represent the skin lining of the nostrils. The skin surface of the main part of the flap away from the observer and part of the raw surface are exposed. This uncovered area was applied to the raw surface of a trap-door flap turned downward from between the eyebrows. The dotted line on the folded tinfoil pattern indicates the actual length of the future nose. The extra amount of the flap below this was required to make the fold constitute the edge of the nostrils.

Figure 346 gives the appearance when this flap was first turned down into place. On the left side an attempt was made to utilize a part of the original ala. This was a great mistake, necessitating the series of operations shown in Figure 347, and the resulting irregularities were never entirely smoothed out. It was often better to eliminate a distorted ala and make an entire new one.

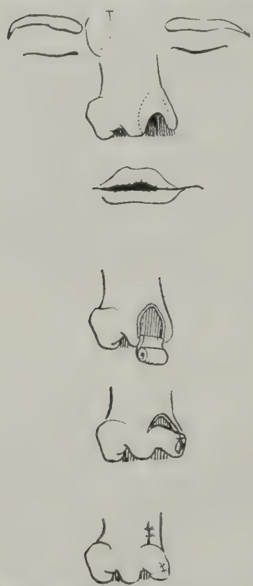

Fig. 347.—Diagrams illustrating correction of left ala.

Figure 348 shows an almost front view of the patient as he came to the reconstruction hospital.

Figure 349 shows result of implanting costal cartilage and shaping up the flap. The left eye, as may be noted, was still lower than the right. The slump of the left upper lip and depression of the eyeball and palpebral fissure were partially corrected by plastic operations, skin graft, and cartilage implant, but this point is still being worked upon.

Figures 350 and 351 are side views from the left of the condition on entering the reconstruction hospital and when last seen. Scars from operations on reconstructed ala may be noted.

Figures 352 and 353 give corresponding views from the right. The upper lip had been raised and given a better shape by turning in part of the original skin of the nose to extend the floor of the nares forward. The columella and the new ala may be noted.

INJURIES TO NOSE.

The nasal defects met with varied from the simplest saddle-nose, without scar, to loss of almost the entire nose. No classical rhinoplastic procedure could be followed in all cases. In each, the method of procedure depended first upon the nature of the defect, and, second, upon the viability of the adjacent tissues. Wherever possible, the Indian method of transposing a flap from the forehead was used. Where the bridge had been lost, cartilage from the fifth or sixth rib was taken, cut the size and shape needed, and planted in the forehead flap before the flap had been freed. This was left in situ for about two weeks before raising and transposing the forehead flap. The base or pedicle of this flap was usually just between the eyebrows. Occasionally, the method used by Lemaître was followed, namely, using the temple as the base, including the temporal artery in the flap. This method had certain advantages, particularly in the fact that it was a very well nourished flap. It

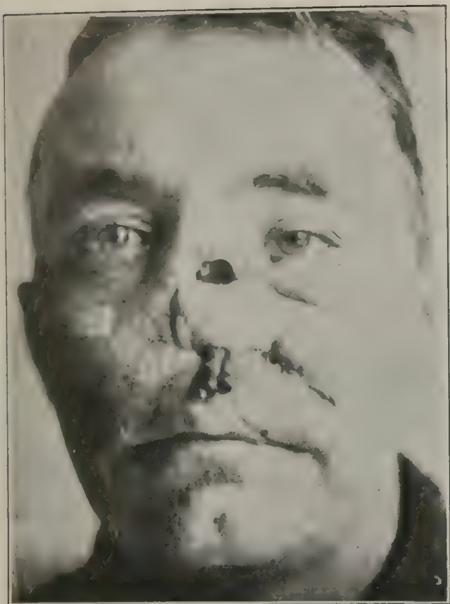

FIG. 348. Front view of patient (Figs. 341–347) on entering reconstruction hospital.

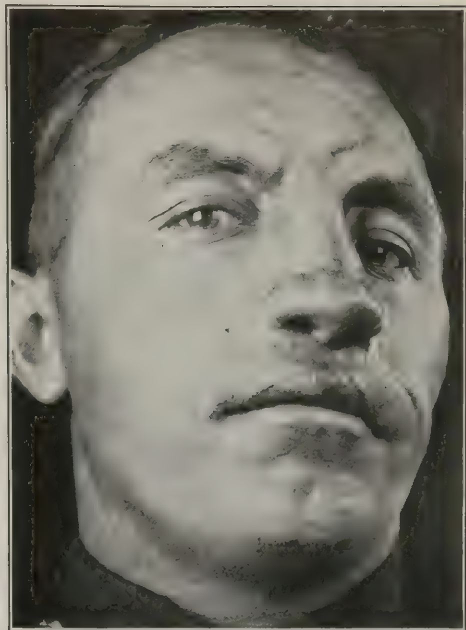

FIG. 349.—Result of implanting costal cartilage and shaping up flap.

FIG. 350.—Left profile on entering reconstruction hospital.

FIG. 351.—Left profile when last seen.

also had the advantage of furnishing an abundance of skin for the repair of defects of the cheek, which so often accompanied nasal defect. The pedicle of the flap could be very easily replaced in the temple and with little or no resulting scar. It was not so good in cases where there was a loss of alæ. Here the forehead flap, with base at the brow, was more advantageous.

In several cases where there was loss of only a small portion of the nasal bridge, cheek flaps were used, and with very good results. The cheek flaps were used also to restore alæ and columella where this was the only loss. In very few cases was it found necessary in rhinoplastic work to transplant large flaps from a distance, but this was a very valuable procedure where the forehead and face would not supply enough tissue. This was done successfully in either of two ways: (1) By attaching the wrist or forearm to the chest or abdo-

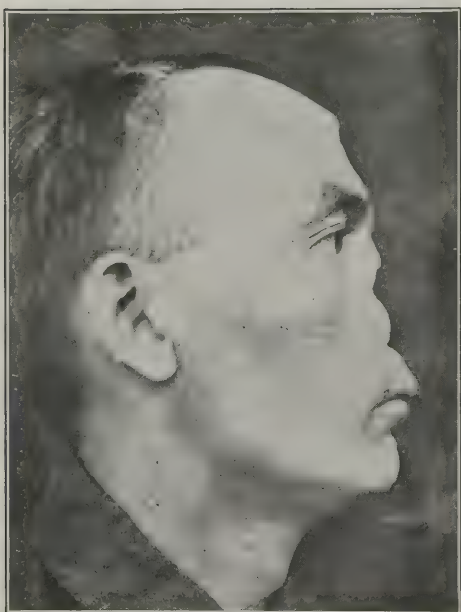

Fig. 352.—Right profile (Figs. 341–351) on entering reconstruction hospital.

Fig. 353.—Right profile when last seen.

men, and later cutting free whatever size flap of skin might be needed. The arm was then supported by splints and bandages in such a manner as to bring the needed flap up to the face. This method was used in a number of cases by Major Gillies, at the Queen's Hospital at Sidcup, England,[15] and also by Mr. Percival Cole, at the King George Hospital in London.[16] (2) By freeing a long flap reaching from the temple or the angle of the jaw to a point on the chest or abdomen, closing the skin under the flap and allowing the flap to remain attached at both ends for several weeks before attempting to transplant it. The edges of the flap were brought together or if not would eventually come together, thus making a tubed flap, through which ample circulation was established to nourish a large free flap, from which rhinoplasty might be done. This method was of value in other plastic operations as well as in rhinoplastics.

There was always some part of the nose that could be preserved, and this, of course, was the first consideration. The tip and alæ are the parts hardest to reproduce, and every bit of these parts that could be saved was a great help in the reconstruction. Whatever remained of the original nose was usually so drawn out of its place that it required careful handling to get it back in place so that it could be used and be made to look natural. A nasal splint was devised to hold these parts in position. Several were made and cast aside, but finally one was completed which answered all purposes very well. This was made by an officer in the dental department at Fort McHenry,[17] and to him belongs much credit for whatever success was accomplished in this particular branch of the work. It should be remembered, however, that many suggestions had been made by other men on the staff, and that some of these suggestions were used in accomplishing the final result. The splint was made of silver, gold plated, and was attached to a cast-silver splint (also gold plated), cemented to the upper teeth. It was so made as to permit every possible motion of the nose pieces, so that it could be readily adjusted to any patient. It could be worn for weeks at a time with very little inconvenience.

The first step, then, in the reconstruction of a nose, after the planting of the cartilage, was to free any part of the nose that remained, to bring it back to its natural position, and to attach it in position by means of the splint.

The next step was the securing of a lining membrane. Mucosa, of course. could not be obtained, but generally epithelial tissue in sufficient quantity could be secured from the adjacent structures, even from the scars themselves, to fill in this want. Considerable ingenuity was sometimes necessary to get and piece together the tag ends of skin and scar to make a complete lining. Where this was impossible on account of the extensive destruction of tissue, a lining was provided by first epithelializing the flap on the under surface, and then bringing it into place already lined. This, however, was not the method of choice, as it made the flap stiff and hard to work with, and shrinkage of the lining almost invariably occurred. The cosmetic result was never so good where this was done. Another method was to turn the flap from the forehead directly over, so that the skin surface formed the lining and left a raw surface exposed, which later covered over with new skin or was skin grafted

Where skin and scar tissue were turned in and sutured together to make the lining, it was necessary to provide some means of holding it closely to the overlying flap, so that firm union would take place. This was done by threading small pieces of rubber tubing with silkworm gut and passing these sutures through the lining from within out, and later passing these sutures through the outer flap and tying over other rubber tubing. The rubber tubing left in the nose had threads attached and left hanging out of the nostrils, so that when these sutures were cut the tubing could be reclaimed from the nose.

The next step in the operation was the transference of the flap and the shaping of the nose. In doing this it was of prime importance that the cartilage, which was brought down with the flap, be properly placed. Where any part of the nasal bridge remained, it was better to bring the cartilage into direct contact with the freshened edges of the bone. To do this the lining was separated at one or more points. Where the bridge was gone, the upper end of the cartilage was beveled to fit against the freshened edge of the frontal bone. Having

no lateral supports, unless the cartilage secured an attachment of freshened bone it would not form a firm bridge; but if an attachment could be secured either to a partially remaining bridge or to the frontal bone a fairly firm bridge resulted. This was provided, of course, that the tissues be held in place by a splint until firm union had taken place. In shaping an ala the ingenuity of the surgeon was often taxed to the utmost. If he was blessed with a little of the dressmaking art he was very fortunate, for this, combined with his surgical judgment, by which to tell just how far he could go and still preserve the viability of his tissues, enabled him to make a shapely nose out of what almost seemed to be an unshapely mass. In order to make measurements for a flap and to get a definite idea as to the size of the flap needed, it was a great help to have a plaster cast made of the man's face and then to mold on it a nose proportionate in size to his other features. From this, accurate measurements were made and the flap outlined in accordance.

It was considered important that the edges of the flap be sutured very carefully to the adjoining skin, so that a nice approximation would result.

The upper edge of the forehead flap could never be smoothed out to make possible a nice union at the bridge between the brows. After firm union had taken place at other points, this part of the flap had to be trimmed, a part of it replaced in the wound, and the brow line straightened.

In removing a large flap from the forehead some consideration had to be given the space remaining. It was customary to undermine the edges of the surrounding skin and to draw this together as far as possible, depending on granulation and the formation of new skin to cover the remaining raw surface. It was surprising to find how smoothly this was accomplished without any aid in the way of skin grafting. The resulting scar on the forehead gradually took on the color and texture of the surrounding skin, soon becoming practically unnoticeable. In other cases excellent results were obtained by the use of full-thickness skin grafts taken from the abdomen.

In two cases cartilage was transplanted from the chest direct to the nose at the same time that the skin flap was transplanted. In both of these it was done successfully, but it was not thought to be the best method, preliminary transplantation of the cartilage being preferred.

The construction of an ala, where this alone was lacking, was done by means of a cheek flap. The scar was excised, the skin turned in from the edge and sutured to the remaining mucosa to line the ala, and a sufficiently large flap taken from the adjacent cheek and sutured in place. This was left in place until there was firm union, and then the pedicle was cut and replaced in the cheek and the ala shaped. This gave very satisfactory results, and the cheek space was easily filled by sliding the adjacent skin together. The same method was used in making a columella in a case where a portion of the septum remained but in which the columella was completely lost. The skin flap from the cheek was sutured to one side of the septal mucosa, and after union the other end of the flap was cut free and sutured to the other side of the septum.

In a number of cases there was saddle-nose, resulting from a crushing blow over the bridge with or without breaking the skin. This was a common accident among aviators and several cases had to be repaired. The contour of the bridge was restored in these cases by making a small incision over the

bridge of the nose, undermining the skin, being careful to get down to the bone and freshening its surface, and then slipping in a piece of costal cartilage cut the proper shape and size to fill the defect. Excellent results were obtained and the very slight scar over the bridge soon faded out, becoming invisible.

The following cases occurred in the services of General Hospital No. 2, Fort McHenry, Md.:

Figure 354 is from drawing in a case of traumatic saddle-nose without scar, which was treated by undermining the skin of the nose through an incision over the base and transplanting a shaped piece of cartilage from the sixth rib.

Figure 355 illustrates a case of traumatic saddle-nose with scar, in which the scar was excised, the skin over the bridge undermined, and cartilage transplanted as in the previous case.

Figures 356 to 358 are from a case of traumatic saddle-nose with extensive scarring of left cheek, treated by excision of scar, transplant of fat to cheek and costal cartilage to bridge of nose.

Figures 359 to 361 illustrate a loss of the right ala alone, with repair by cheek flap.

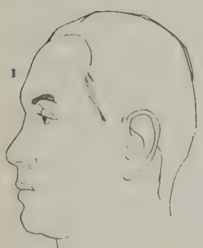

FIG. 354.—Diagrams of repair of saddle nose without scar.

FIG. 355.—Diagrams of repair of saddle nose with scar.

Figures 362 to 365 show a case of defect of the upper lip with loss of the columella nasi. The lip was repaired by sliding cheek flaps and the columella by transposed cheek flap.

The case seen in Figures 366 to 372 is shown especially to illustrate the use of the nasal splint described above (p. 525). There was a defect of the right ala with depressed scar of left side of bridge, giving the effect of saddle-nose. This was repaired by excision of scar, readjustment of tissues without flap, and insertion of costal cartilage.

Figures 373 to 379 illustrate a defect of tip, lower part of bridge and both alæ, repaired by cheek flap and cartilage to bridge and later by fat cheek flap to repair tip. Use of splint is also shown.

Figures 380 to 384 are from a case with defect of upper part of bridge with almost complete loss of nasal bones and loss of both eyes. Repaired by excision of scar, lateral flaps, and costal cartilage.

Figures 385 to 389 are from a case of loss of entire upper part of nose, in which attempted repair, at an evacuation hospital, by forehead flap failed by reason of slipping of flap. Late repair was accomplished by readjustment of this flap and the addition of costal cartilage, transplanted at the time of the readjustment of the flap.

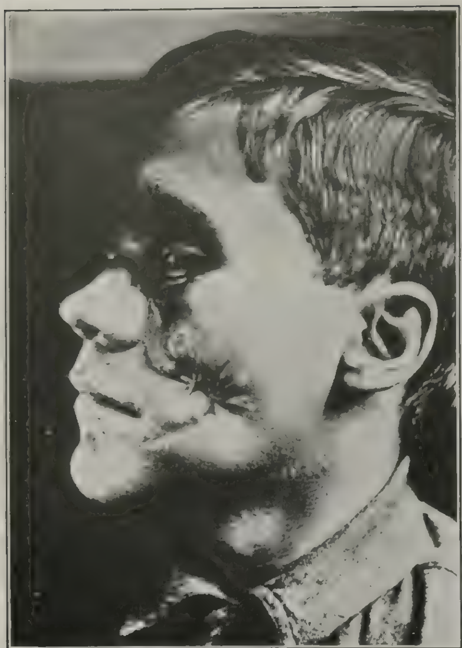

Fig. 356.—Traumatic saddle-nose with extensive scarring of left cheek.

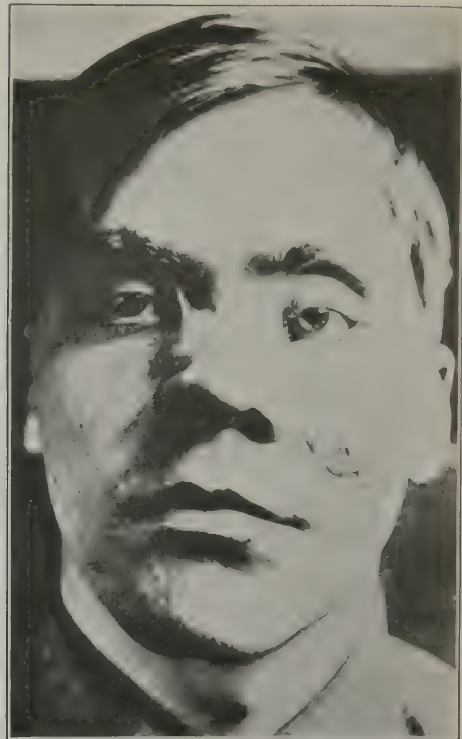

Fig. 357.—Another view of same case, before operation.

Fig. 358.—Appearance after excision of scar, transplant of fat graft to cheek, and costal cartilage to nose.

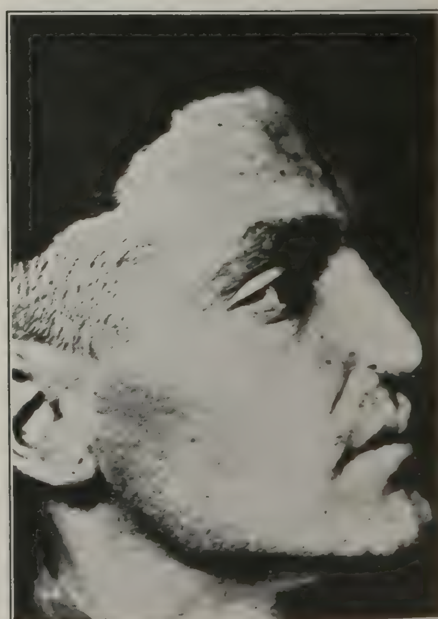

Fig. 359.—Loss of right ala of nose.

Figures 390 to 395 illustrate a case of loss of upper part of bridge, right nasal bone, both eyes, opening into both frontal sinuses and into right maxillary sinus. Repaired by inverted flap from forehead, using skin for lining, the raw surface being left to granulate.

Figures 396 to 404 show a case of extensive loss of lower part of nose, both nostrils being occluded, nothing being left of right ala, and left ala being badly

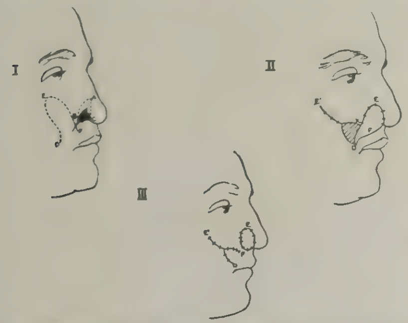

FIG. 360.—Diagrams illustrating repair of ala by cheek flap.

FIG. 361.—Showing restoration of right ala (Figs. 359–360).

FIG. 362.—Defect of upper lip with loss of columella nasi.

FIG. 363.—Diagrams showing lip repair by sliding cheek flaps.

twisted out of position. Repaired by forehead flap with temporal pedicle, cartilage being transplanted from chest at same time flap was transplanted from forehead.

Figures 405 and 409 show a complete loss of the bridge, the tip and alae being left and turned up. Repaired by forehead flap, base at brow line, the cartilage having been placed in flap three weeks previous to cutting flap. The flap was turned down over a nasal splint, leaving a bad fold of skin at the brow line, which was later trimmed and replaced. Both nostrils had been occluded, but the operation gave a perfect functional result. The patient was later transferred for a further plastic operation on the tissues near the eye.

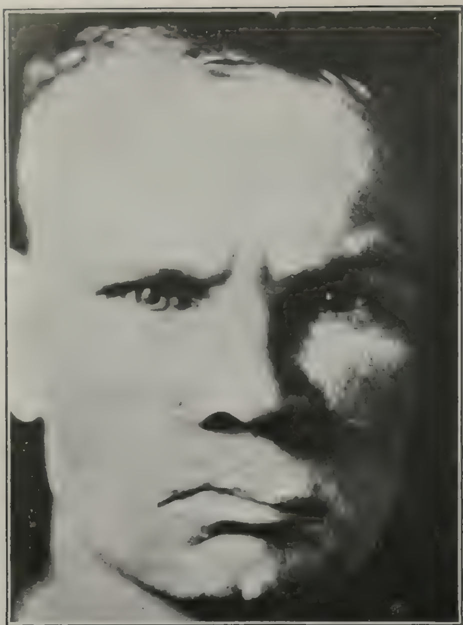

FIG. 364.—Appearance after lip repair (Figs. 362–363).

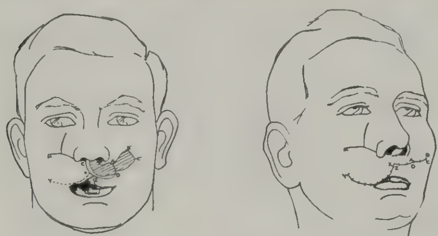

FIG. 365.—Diagrams illustrating reconstruction of columella.

FIG. 366.—Side view of defect of right ala with depressed scar of bridge, giving the effect of saddle-nose.

FIG. 367.—Front view of same case.

FIG. 368.—Repair by excision of scar, readjustment of tissues without flap, and insertion of costal cartilage. Front view during treatment, showing splint in position.

FIG. 369.—Left view, showing splint (Figs. 362–368).

FIG. 370.—Right view of same case.

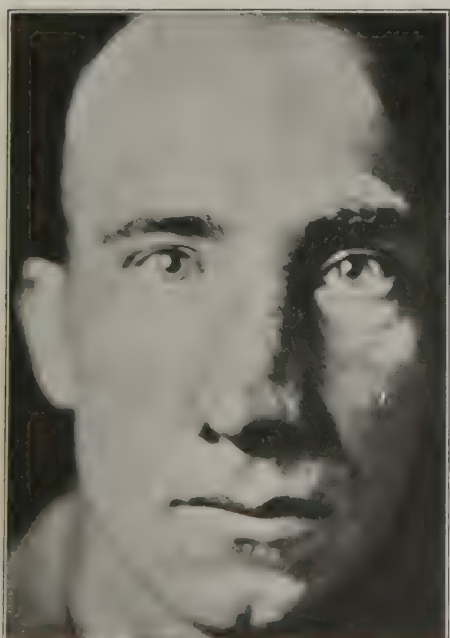

FIG. 371.—Front view after operation.

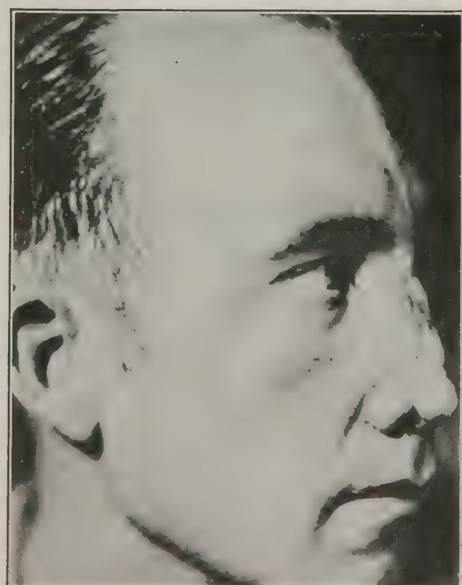

FIG. 372.—Side view after operation.

FIG. 373.—Defect of tip, lower part of bridge, and both alæ, side view.

FIG. 374.—Same case, front view.

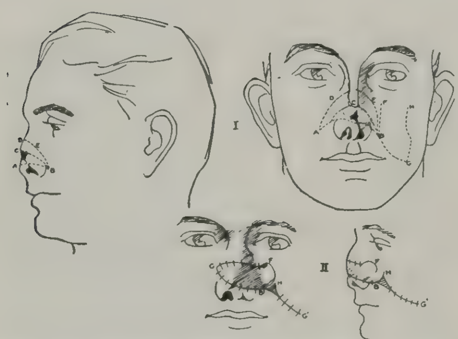

FIG. 375.—Diagrams indicating first operation to bring tip down into normal position and filling of gap over bridge by cheek flap.

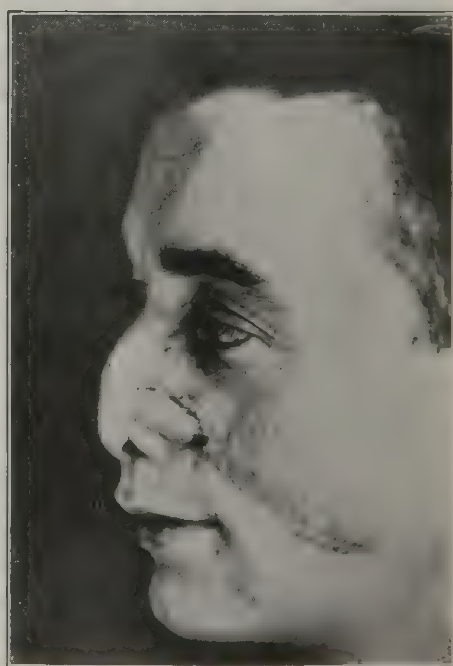

FIG. 376.—After operation indicated by diagrams in Fig. 375.

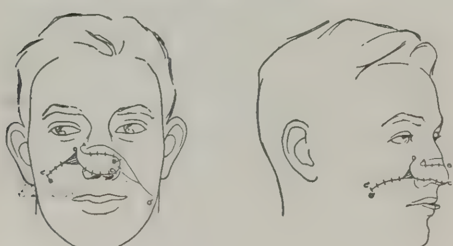

FIG. 377.—Diagrams illustrating building out of tip of nose with flap of skin and fat from cheek.

FIG. 378.—Front view shortly after operation illustrated in Fig. 377.

FIG. 379. Side view of same stage. Splint in position to support tip of nose.

FIG. 380.—Defect of upper part of bridge with almost complete loss of nasal bones and both eyes.

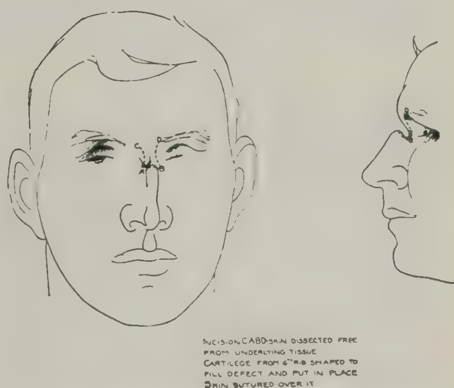

FIG. 381.—Diagrams illustrating repair by excision of scar, lateral flaps, and costal cartilage.

FIG. 382.—Diagrams showing completion of operation.

FIG. 383.—Appearance after operation (Figs. 380–382).

FIG. 384.—Front view after operation, artificial eyes inserted.

FIG. 385.—Loss of upper part of nose, showing attempted early repair by forehead flap.

FIG. 386.—Front view of same case.

FIG. 387.—Diagrams illustrating operations (Figs. 385-386).

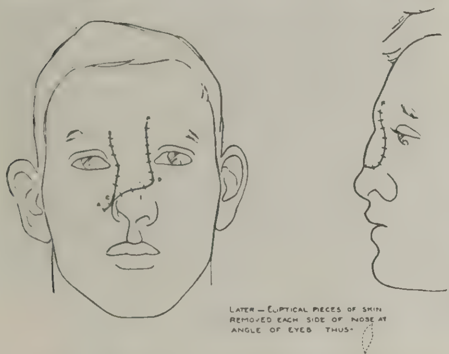

FIG. 388.—Diagrams illustrating operations.

FIG. 389. Appearance after operation.

FIG. 390. Loss of upper part of bridge and both eyes, opening into both frontal and right maxillary sinuses.

FIG. 391.—Another view of same case.

FIG. 392.—Repair by inverted flap from forehead, using skin for lining, raw surface left to granulate. Front view after operation (Figs. 390–391).

FIG. 393.—Side view after operation.

FIG. 394.—Front view showing cicatrization almost complete.

FIG. 395.—Side view at same stage of treatment.

Fig. 396.—Extensive loss of lower part of nose, both nostrils occluded, nothing left of right ala, left ala badly twisted out of position.

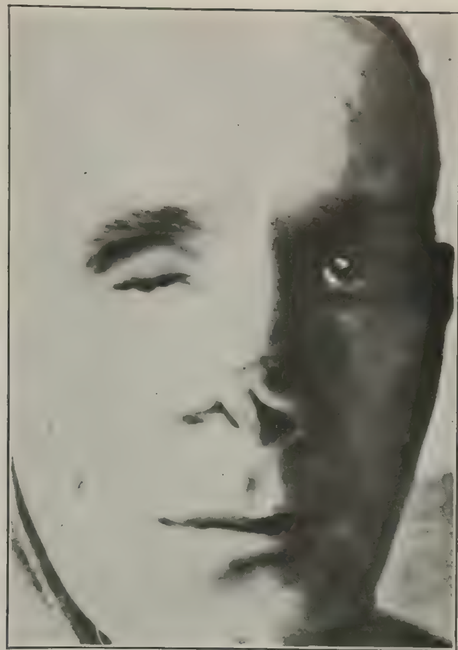

Fig. 397.—Front view of same patient.

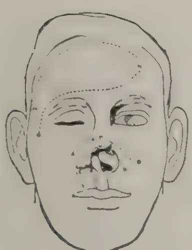

Fig. 398.—Diagrams showing repair by forehead flap with temporal pedicle and costal cartilage transplant.

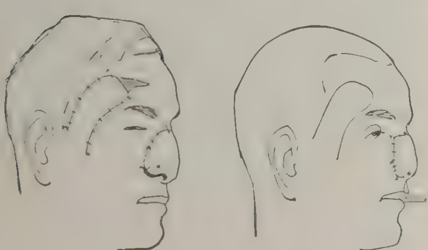

Fig. 399.—Diagrams showing flap cut free, pedicle returned, and ala reconstructed.

Fig. 400.—Showing forehead flap with temporal pedicle sutured into nose.

FIG. 401.—Flap cut free and pedicle returned to original position (Figs. 396–400).

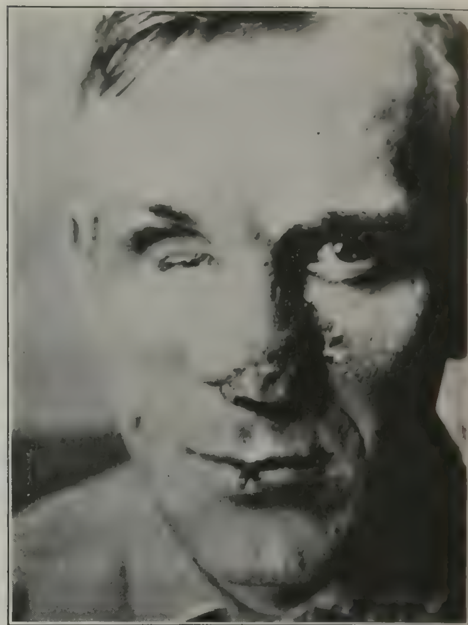

FIG. 402.—Later stage of same case (Fig. 401).

FIG. 403.—Final result, artificial eye in place.

FIG. 404.—Final result, front view.

Figures 410 to 417 illustrate a complete loss of the nose except the right ala and tip, loss of left eye, and deep scarring of left cheek. Repaired by forehead flap, cartilage having been previously inserted. Left side of flap did not live, requiring later repair by another flap from left side of forehead, with good result functionally and fair result cosmetically. Forehead allowed to granulate in each case, with very little evident scar remaining.

Figures 418 and 419 are from a case of loss of entire bridge with preservation of tip and alæ. Repaired by forehead flap and cartilage transplant with good functional and cosmetic result.

FIG. 405.—Complete loss of bridge of nose, tip and alæ being turned up.

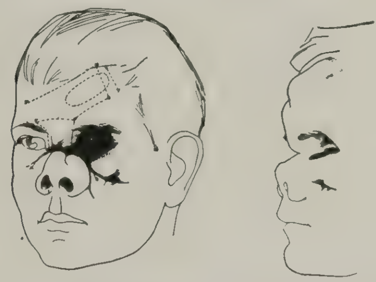

FIG. 406.—Diagrams showing outline of forehead flap and cartilage transplant embedded beneath it for later transfer to nasal defect.

FIG. 407.—Diagrams showing forehead flap and costal cartilage brought down and sutured into nasal defect.

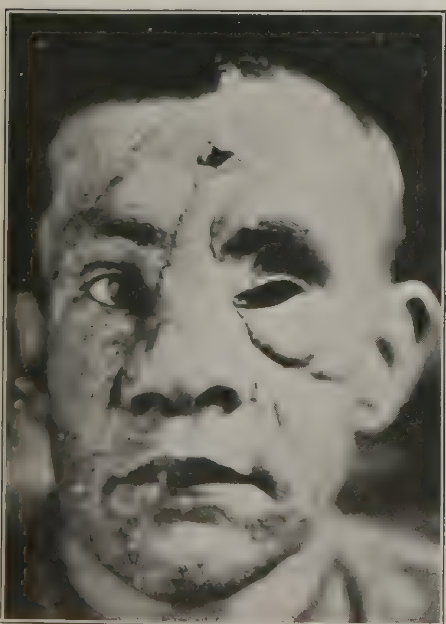

FIG. 409.—Appearance shortly after nasal plastic.

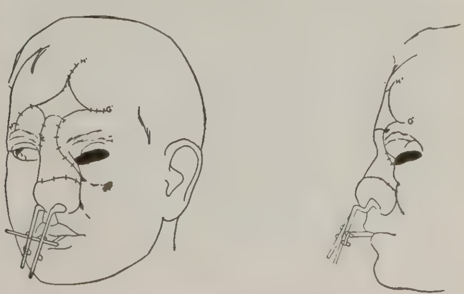

FIG. 408.—Diagrams showing pedicle severed and returned to forehead.

The following cases occurred in the service of the Walter Reed General Hospital:

Figures 420 to 423 illustrate a case of loss of the tip of the nose, treated by transfer of a forehead flap with pedicle at the brow.

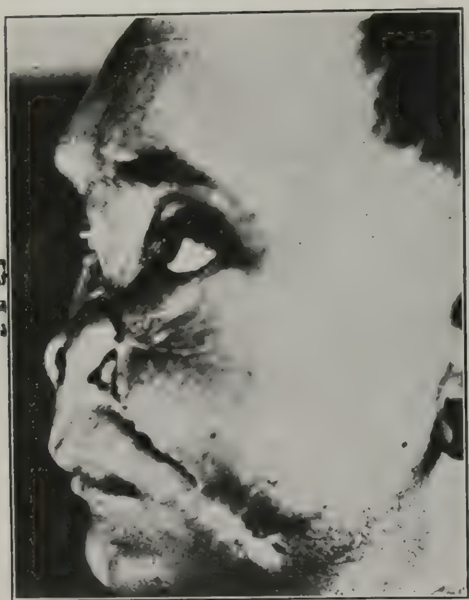

Fig. 410.—Complete loss of nose except right ala and tip, loss of left eye, and deep scarring of left cheek.

Fig. 411.—Front view of same case.

Figures 425 to 432 are from a case of extensive wound of right cheek and destruction of bridge of nose. Repaired by plastic operation of cheek and insertion of costal cartilage beneath skin of nose.

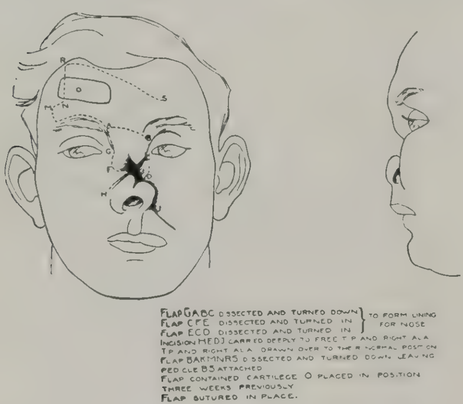

Fig. 412.—Diagrams illustrating outline of forehead flap and insertion of costal cartilage.

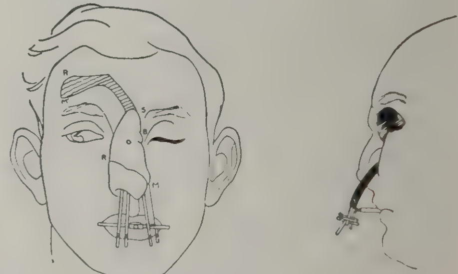

Fig. 413.—Diagrams showing flap brought down and sutured into nasal defect.

Figures 433 to 439 show a loss of right eye and nasal bones with overlying soft tissue. Repair of nasal defect by forehead flap brought down two weeks after implantation of costal cartilage beneath skin of forehead. Artificial eye inserted later.

FIG. 414.—Side view after transplantation of forehead flap and costal cartilage (Figs. 410–413). Note splint attached to teeth.

FIG. 415.—Front view at same stage.

FIG. 416.—Shows failure of repair on left side owing to sloughing of flap. This required a second flap from forehead.

FIG. 417.—Final result.

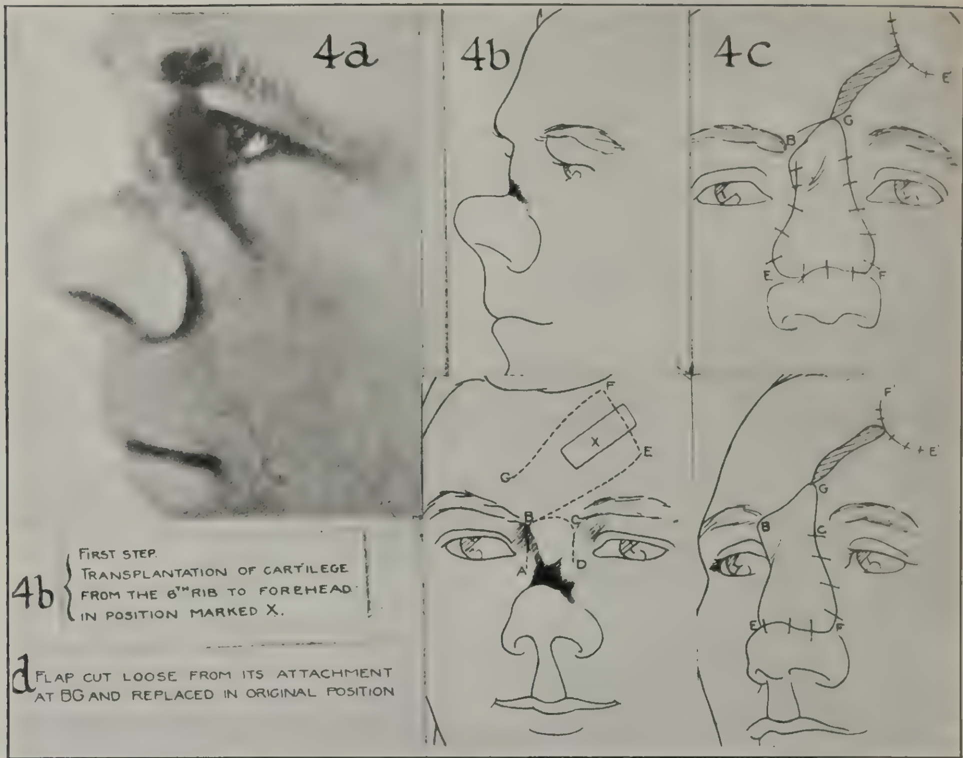

FIG. 418.—Loss of entire bridge with preservation of tip and alæ. Diagrams showing repair by forehead flap and costal cartilage transplant.

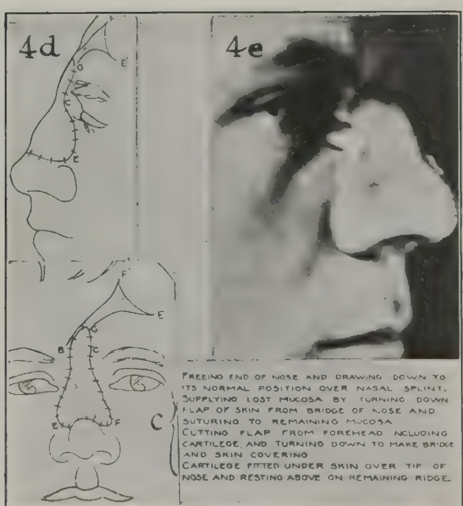

FIG. 419.—Diagrams showing further operative stage and photograph of final result.

FIG. 420.—Loss of tip of nose by machine-gun bullet. Front view.

FIG. 421.—Same case (Fig. 420). Profile view.

FIG. 422.—Forehead flap brought down and sutured into raw surface at tip of nose.

FIG. 423.—Restoration of tip by forehead flap, pedicle severed and returned to forehead.

FIG. 424.—External nasal support attached to dental splint, used for retention of bridge of nose in proper position.

Fig. 425.—Extensive wound of right cheek, destruction of bridge of nose, and fracture of upper jaw. Photograph taken in A. E. F. shortly after injury. Wound represents exit of machine-gun bullet.

Fig. 426.—Photograph taken later in A. E. F., showing splint for upper jaw supported by headgear.

Fig. 427.—Healed wound of entrance just in front of left ear.

Fig. 428.—Appearance after cicatrization of wound of exit.

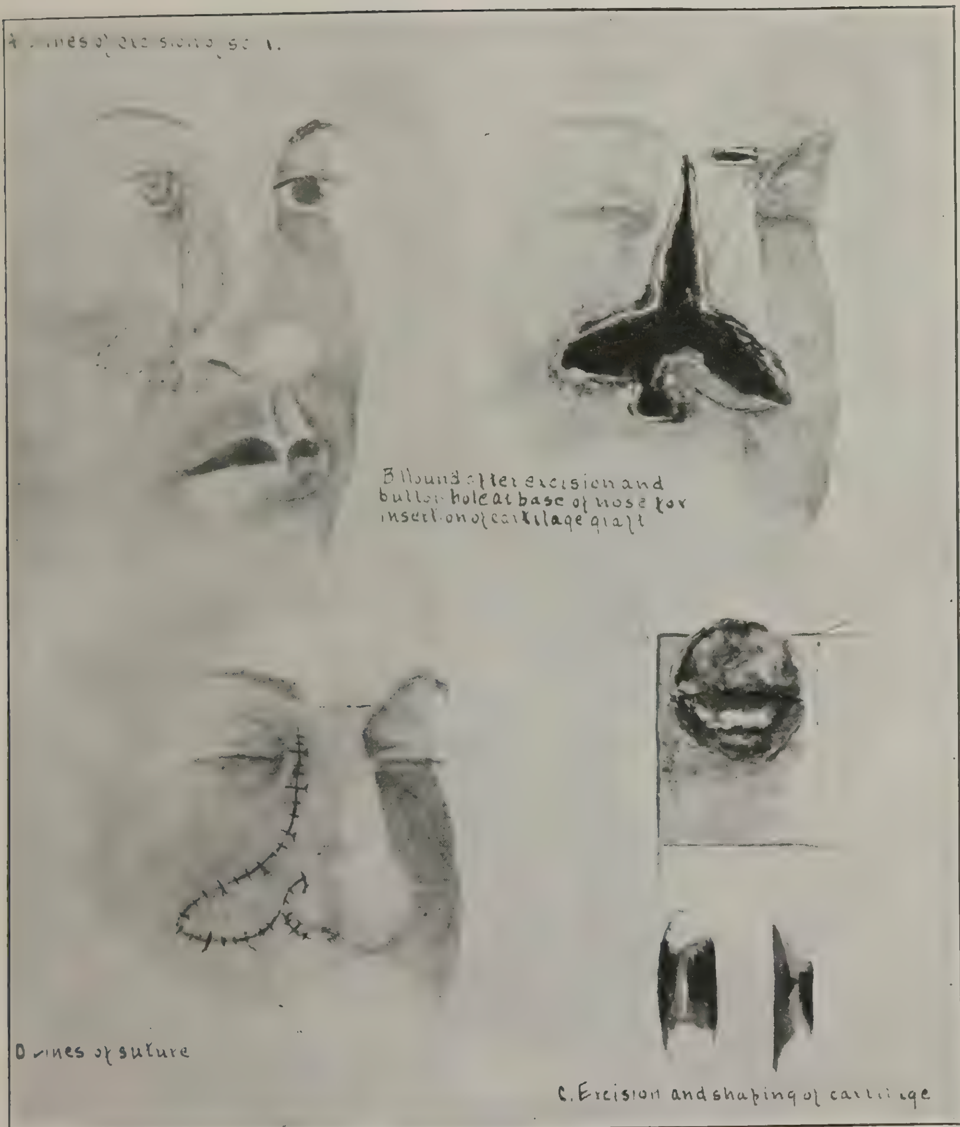

FIG. 429.—Diagrams illustrating excision of scar tissue, plastic repair, and restoration of bridge of nose by costal cartilage transplant (Figs. 425–428).

Fig. 430.—Shows application of external nasal splint supported by headband (Figs. 425–429).

Fig. 431.—Front view after operation, same case. Cartilage transplant is not exactly straight.

Fig. 432.—Profile view of completed case.

FIG. 433.—Loss of right eye and nasal bones with overlying soft tissue.

FIG. 434.—Another view of same case (Fig. 433).

FIG. 435.—Cartilage transplant inserted beneath skin of forehead preliminary to bringing down flap to fill nasal defect. Artificial eye in place temporarily.

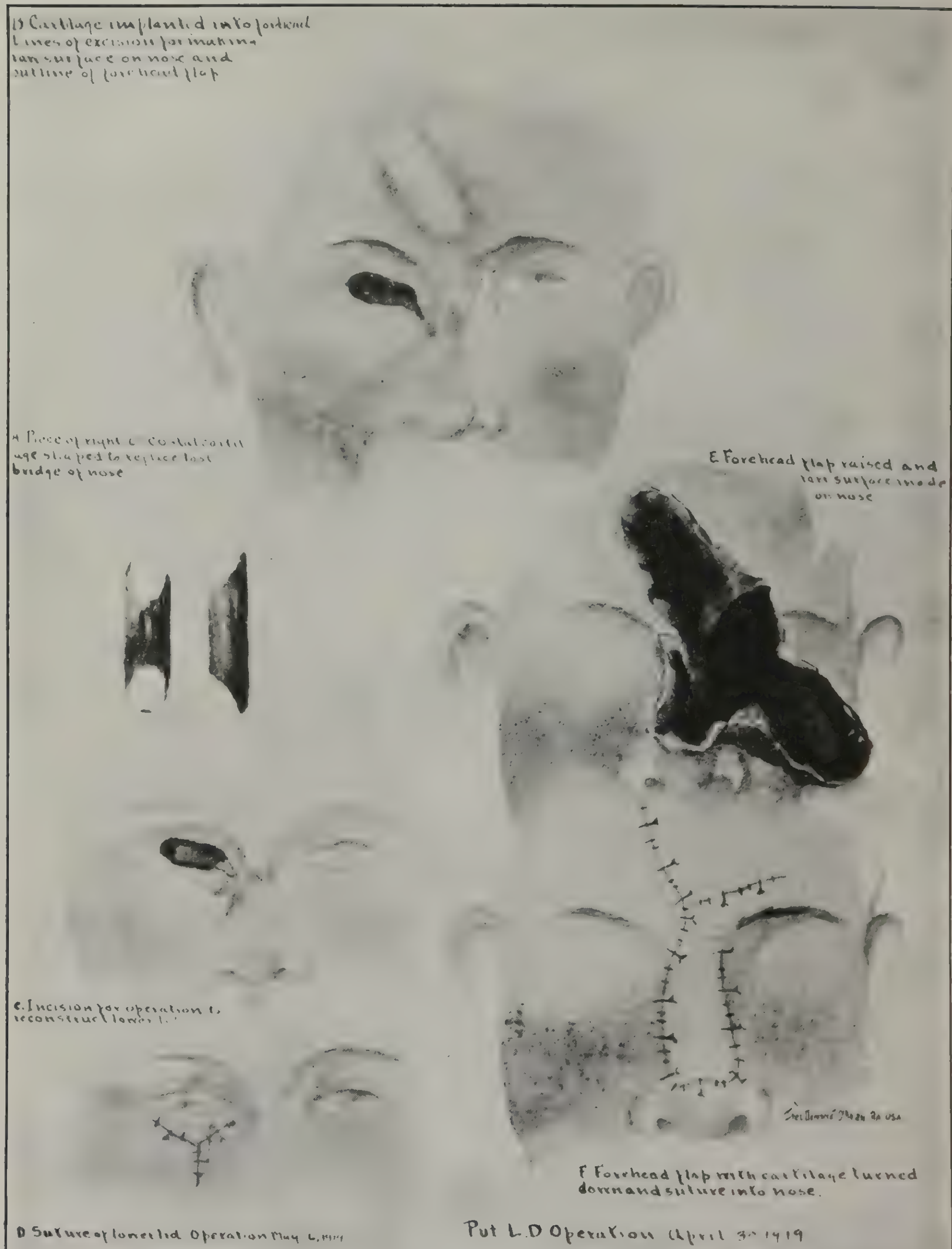

FIG. 436.—Diagrams illustrating cartilage transplant, forehead flap, and eyelid plastic (Figs. 433–435).

FIG. 437.—Appearance immediately after suture of forehead flap containing cartilage into nasal defect (Figs. 433–436).

FIG. 438.—Front view of same patient after trimming of pedicle.

FIG. 439.—Lateral view of same patient. Permanent artificial eye inserted later.

PHYSIOTHERAPEUTIC TREATMENT OF MAXILLOFACIAL INJURIES.

The treatment of maxillofacial injuries during the intervals between the surgical steps necessary to repair, was largely entrusted to the department of physiotherapy. Physiotherapy supplies both a stimulation and a control over the growth of the tissues along the required lines. The benefit derived from the application of physical measures to tissues transplanted to new positions or engrafted upon new foundations was amply demonstrated, and it was found that the increased cell activity resulting from the consequent stimulation materially shortened the correction of the serious defects encountered in these cases. The immobilization of the parts by the splints and devices used by the maxillofacial surgeon was overcome to a large degree by massage and manipulation of the forcibly immured tissues, nerves, blood vessels, and lymph channels reacting favorably and responding to the treatment by improved function and reparative growth. The tendency to fibrosis and contracting tendinous attachments following plastic operations was chiefly obviated by gentle and continued stretching, the application of heat, properly applied electrical modalities, and massage, combined with the energizing influence of the actinic ray. The sum total of treatment not only hastened the reparative process through its different stages, but actually lessened the disfigurement.

FIG. 440.—High frequency nonvacuum treatment of scars resulting from maxillofacial injury.

The initial treatment used for facial scars was heat, applied by means of the high-frequency current through a nonvacuum glass electrode lined with sterling silver (Fig. 440). This current was a combination of high voltage and high frequency with an infinitesimal amperage, which was not measured, as the sensitiveness of the skin varied greatly in individuals and it was necessary to use only a strength of current generating an amount of heat that could be comfortably borne. Talcum powder applied over the region of the scar and adjacent area allowed the flat surface of the electrode to be slowly and successively moved over the surface, producing a warmth that was pleasant and that exerted a sedative effect where hyperesthesia existed. From 10 to 15 minutes of treatment sufficed, in the average case, to produce the required hyperemia; the area was then immediately massaged (Fig. 441), the thumb and finger tips being used to gently but firmly loosen the adherent portions of the scar. The use of cocoa butter on the part during the massage and manipulation assisted in softening the tissues and in rendering the skin pliable. Very recent grafts or those that were delicate and not firmly attached were massaged gently and the high-frequency treatment omitted until the attachment was firm.

Where scar tissue had become thickened with old fibrous growths, it was useless to attempt to soften these by high-frequency current and massage alone, negative galvanism then being resorted to for its solvent effect (Fig. 442). This process is called ionization and the technique was simple. The positive pole or electrode saturated with a salt solution was applied to the posterior cervical region and held or secured firmly in place to obtain good contact. The negative electrode, fashioned from sheet block-tin or from copper-mesh wire and cut to accurate size of the fibrosed portion of the scar, was covered with cotton or gauze wet in salt solution and placed in position for treatment. When the circuit was closed, the rheostat was slowly advanced until the required milliamperage was obtained, five to six milliamperes being ordinarily used. It was at times necessary to close the rheostat and to adjust one or both of the electrodes in beginning the treatment, but when all points

Fig. 441.—Massage of scars resulting from maxillofacial injury.

Fig. 442.—Galvanism with negative pole (ionization) to fibroid scar of face.

of the technique were correct, the current was allowed to flow for from 5 to 10 minutes. This treatment was repeated daily unless some contraindication arose and was followed, of course, by high frequency and massage to the remainder of the scar. Especial attention was given to the area slowly softening under negative galvanism, in an endeavor to progressively loosen it from the underlying tissues, which was usually fully attained after continuous treatment.

Where a redundancy of tissue existed at the junction of radiating scar lines, a small ulceration sometimes occurred to delay repair. The offending granulation could be removed by fulguration, using the high-frequency fulguration needle mounted on a handle, to which was connected a cord running to the high-frequency machine. The needle was approached to within one-eighth inch of the granulating area and the high-frequency current left the needle in a rapid stream of hot sparks possessing a cauterizing effect. This

stream of sparks could be directed to a very small area under the point of the needle, thus allowing the destruction of tissue to be very accurately controlled. Only a light eschar was produced at a single treatment, which was repeated if necessary until the object in view was attained, the stimulation of normal granulation and the smoothing out of the redundant portion of the scar.

In some maxillofacial injuries a severe trigeminal neuritis was a disagreeable feature, baffling to the surgeon and extremely distressing to the patient. By covering the painful area with the positive electrode and using the galvanic current for a few minutes, the acute pain was often allayed; with several treatments it was sometimes entirely relieved. (Fig. 443.) Where the course of the affected nerve was quite evident, the application of the actinic ray was tried. The Kromayer or water-cooled actinic-ray lamp was used, to which was fitted a quartz-glass lens of suitable dimension for treatment. (Fig. 444.) In facial work

Fig. 443.—Galvanism with positive pole for relief of neuritis resulting from maxillofacial injury.

Fig. 444.—Treatment of ulceration with actinic ray.

this lens needed to be only one-half inch in diameter and was attached to the lamp over the anterior window. With the lamp in operation and the current adjusted to proper intensity, the lens was pressed firmly upon the skin over the course of the nerve and an exposure of one-half minute given. The lens was then moved one-half inch further along the nerve and another similar exposure made, continuing in this manner until the apparent distribution of the neuritis was covered. This treatment, which reached deeply through the skin and intervening structures to the nerve trunk, was not destructive in any sense but it excited an active physiological congestion, quite evident on the surface where the lens had rested, as a bright red spot sometimes accompanied by blistering and the production of blebs on the skin at the point of contact. The reaction began about three hours after the treatment but subsided fully in a few days without any harm to the tissues. The effect of the actinic ray upon the nerve

trunk was to allay the congestion, which gave rise to the neuritis, and many cases were relieved with one treatment. If necessary to give a second treatment, the intervals left between the lens spots of the first treatment were utilized, and in the event that a third treatment seemed desirable the area of the first treatment had by that time returned to normal condition.

Peripheral facial nerve paralysis was often encountered in maxillofacial injuries, due either to the original gunshot wound or to postoperative involvement of the nerve trunks, where there was more or less adhesion or advanced reaction of degeneration. The exercise of the affected muscles was best accomplished by careful use of the interrupted galvanic current to stimulate the nerves and to produce muscular contractions by chemical action upon the muscle tissue itself. When muscular response was obtained, the slow sinusoidal current was substituted which, with the rise and fall of potential, was the best method of treating weakened muscles. Where the reaction of degeneration had not occurred, faradism could be used with benefit and an early return of function of the muscle secured. (Fig. 445.)

Fig. 445.—Faradism for muscle stimulation in peripheral nerve paralysis.

In using either the faradic or the slow sinusoidal current, the indifferent electrode was placed on the posterior cervical region and the active electrode applied to the motor point of the muscle to be exercised, stimulation being repeated from 6 to 12 times, according to the condition of the muscle. In using the interrupted galvanic current, the positive electrode was placed on the posterior cervical region and the negative electrode was used actively at the motor point of the muscle. The stimulation induced an increased blood supply, and absorption of inflammatory products, and favored the nutrition of the muscle, while progressive exercise enhanced muscular tone.

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SECTION III.

OPHTHALMOLOGY IN THE UNITED STATES.

INTRODUCTION.

The material on which this section is based consists of the records of the activities of the eye services in the United States of 44 general hospitals, 39 camp base hospitals, 3 department base hospitals, 3 embarkation base hospitals, 5 debarkation hospitals, and 1 camp infirmary, from the date of their establishment until the early portion of 1919 (none later than April 1, 1919). The reports of the attending surgeon's office, Washington, D. C., and of the School of Ophthalmology, Fort Oglethorpe, Ga., have also been utilized. The hospital records are filed in the Office of the Surgeon General.[1] A series of special reports were secured by means of a letter [2] sent to the commanding officers of each of the hospitals listed. These are also on file in the Surgeon General's Office.[1]

REFERENCES.

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(2) Circular Letter No. 6, Surgeon General's Office, Jan. 2, 1919. Subject: Activities of Eye Service Since its Establishment. On file, Record Room, S. G. O., 322.3 (Ophthalmological Units).

CHAPTER I.

STATISTICS.

The statistics presented here were compiled from special reports submitted by the ophthalmic medical officers on duty at the various military stations throughout this country and are now filed in the Office of the Surgeon General. They must not be confused with the data relative to diseases of the eye which are given in Part II of Volume XV of this history, which were derived from the register cards of sick and wounded. In certain instances men who were treated and reported by the ophthalmologist were not actually placed on sick report, hence no sick and wounded cards were prepared for them.

TABULATION OF DISEASES OF THE EYE.[a]

Diseases and injuries of eyelids and brow.

Eyelid:	
abscess	18
alopecia	1
angioma	5
ankyloblepharon	4
blepharitis	1, 955
blepharospasm	88
blepharochalasis	1
burns	32
carcinoma	11
chalazion	2, 127
concretions	2
contractions	22
contusions	125
dermatitis	191
dermatitis, poison ivy	3
distichiasis	14
ecchymosis	116
ectropion	102
eczema	19
edema	168
emphysema	18
entropion	3
epicanthus	1
epithelioma	4
erysipelas	23
fibroma	2
foreign bodies	147
herpes	1
herpes zoster	8
hematoma	1
hordeolum	2, 730
injuries unclassified	129

Diseases and injuries of eyelids and brow—Con.

Eyelid—Continued.	
insect bite	6
lacerations	55
lagophthalmos	11
lipoma	1
malignant pustule	1
melanoma	2
milium	4
molluscum	2
nævus	8
papilloma	17
phlegmon	18
phthiriasis	1
pigmented mole	1
pruritis	1
tarsitis	1
trichiasis	34
tuberculosis	2
tumor	4
ulcer, syphilitic	2
wounds, incised	6
xanthelasma	2
Brow:	
wounds	6
	8, 256

Diseases and injuries of conjunctiva and caruncle.

Conjunctiva:	
abscess	1
angioma	1
argyrosis	395
burns	126
chemosis	21

[a] For help in preparing the statistical tables the writer is indebted to Dr. A. G. Fewell, formerly first lieutenant, Medical Corps.

Tabulation of diseases of the eye—Continued.

Diseases and injuries of conjunctiva and caruncle—Continued.

Conjunctiva—Continued.	
conjunctivitis—	
catarrhal	15, 897
contagious, acute	5, 879
chemical	169
chronic and subacute	2, 865
diphtheritic	8
diplobacillus	14
exanthematous	1
follicular	628
gonorrheal	117
hemorrhagic	27
mechanical and traumatic	11
phlyctenular	419
poisonous gas	88
solar	72
trachomatous (trachoma)	1, 749
vernal	39
contusions	13
cysts	6
emphysema	2
foreign bodies	250
granuloma	11
hemorrhage, subconjunctival	198
herpes	5
hyperemia	89
injuries	45
lacerations	21
lipoma	2
lithiasis	8
lymphangiectasis	1
mixofibroma	2
ophthalmia neonatorum	1
papilloma	4
pemphigus	1
pinguecula	42
pterygium	1, 126
symblepharon	52
tuberculosis	2
ulcer	4
xerosis	1
Caruncle:	
abscess	1
papilloma	2
	30, 416

Diseases and injuries of cornea and sclera.

Cornea:	
abscess	8
arcus senilis	1
conical	63
dermoid cyst	1
fistula	1
injuries –	
abrasions	344
burns	43
foreign bodies	2, 160
wounds	44

Diseases and injuries of cornea and sclera—Con.

Cornea—Continued.	
keratitis	186
disciformis	9
fascicular	1
herpetic (dendritic)	45
hypopyon	29
interstitial, syphilitic	53
marginalis	18
mycotic	1
parenchymatous	430
phlyctenular	146
profunda	3
punctate	8
sclerosing	1
superficial	46
ulcerative	828
unclassified	5
keratoglobus	1
keratoiritis	50
keratomalacia	2
leucoma	1, 102
pannus	34
ulcers of, infected	659
ulcers of, unclassified	26
Sclera:	
episcleritis	239
hemorrhage	1
injuries—	
foreign bodies	2
lacerated	4
punctured	3
scleritis	94
	6, 691

Diseases and injuries of anterior chamber, iris, ciliary body, and choroid.

Chorioretinitis	12
syphilitic	12
Choroid, injuries of:	
rupture	38
rupture of, and retina	29
sarcoma	1
tuberculosis	1
Choroiditis	544
acute	4
atrophic	47
central	64
diffuse	38
disseminated	84
exudative	208
guttate	1
myopic	1
suppurative	9
syphilitic	53
traumatic	25

Tabulation of diseases of the eye—Continued.

Diseases and injuries of anterior chamber, iris, ciliary body, and choroid—Continued.

Ciliary body:	
gumma	1
Cyclitis	9
Sympathetic irritation	3
Sympathetic ophthalmia	1
Uveitis	47
chronic	3
syphilitic	7
tuberculous	1
Iris:	
aniridia	2
anisocoria	30
atrophy	4
bombé	1
melanoma	1
Hippus	2
Iridochoroiditis	1
Iridocylitis	132
Iridodialysis	52
Iridodonesis	15
Iridoplegia reflex	15
Iritis	793
acute	262
chronic	7
papulosa	7
plastic	25
serous	16
syphilitic	110
chronic	11
traumatic	18
Pupil, occlusion of	5
Synechiæ, anterior	57
Synechiæ, posterior	71
Congenital anomalies of iris:	
albinism	5
coloboma	65
heterochromia	10
persistent pupillary membrane	11
polycoria	8
Anterior chamber:	
cilia in	1
blood in	8
	3, 188

Diseases and injuries of retina and optic nerve.

Retina:	
angiosclerosis	10
atrophy	17
commotio of	2
degeneration	3
detachment	85
embolism of central artery	4
embolism of lower temp. branch	1
Gunn's dots	11
hemeralopia	3

Diseases and injuries of retina and optic nerve—Continued.

Retina—Continued.	
hemorrhage in	36
hemorrhage, subhyaloid	1
hyperemia	3
hyperesthesia	9
injuries, rupture of	11
macular, hole	8
multilocular cysts	1
nyctalopia	27
retinochoroiditis	19
retinitis	338
albuminuric	50
chronic	14
circinata	2
diabetic	5
hemorrhagic	44
pigmentosa	102
proliferans	21
punctate	1
solar	4
syphilitic	58
thrombosis of central vein	1
Congenital anomalies of retina:	
coloboma of retina and choroid	6
Optic nerve:	
amblyopia, toxic	29
atrophy	373
syphilitic	23
choked disc	179
optic neuritis	263
syphilitic	14
pseudoneuritis	121
retrobulbarneuritis	39
unclassified diseases	42
anomalies—	
coloboma of disc	6
medulated nerve fibers	59
unclassified	1
	2, 046

Diseases and injuries of lens.

Lens:	
aphakia	32
cataract—	
anterior polar	28
capsular	15
cærulea	1
complicated	4
congenital	54
immature	250
cortical	6
nuclear	4
posterior polar	23
punctate	1
secondary	3
senile	7
traumatic	244

Tabulation of diseases of the eye—Continued.

Diseases and injuries of lens—Continued.

Lens—Continued.	
dislocation	24
congenital anomalies—	
coloboma of	1
lenticonus	2
	699

Diseases and injuries of vitreous.

Vitreous:	
cysticercus	1
fluidity	17
hemorrhage	34
opacities	327
synchysis scintillans	6
congenital anomalies—	
persistent hyaloid artery	10
	395

Diseases and injuries of exterior and interior ocular muscles and their nerve supply.

Bell's palsy	17
Esophoria	201
Exophoria	156
Heterophoria	13
Hyperphoria	47
Nystagmoid movements	45
Nystagmus	251
Ophthalmoplegia:	
complete	26
exterior	44
interior	6
Paralysis of—	
abducens and facial	11
external rectus	27
inferior oblique	5
internal rectus	6
oculomotor	22
superior rectus	3
superior oblique	2
Paresis of exterior ocular muscles, unclassified	28
Ptosis	71
Ptosis, congenital	45
Spasm of—	
ciliary muscles	3
exterior ocular muscles	1
Strabismus:	
alternating	57
convergent	671
divergent	362
unclassified	394
vertical	4
Unclassified diseases	48
	2, 607

Anomalies of refraction.

Amblyopia, refractive	74
Anisometropia	129
Astigmatism:	
hyperopic	1, 653
hyperopic, compound	6, 987
irregular	14
mixed	1, 620
myopic	1, 559
myopic, compound	1, 525
Emmetropia	5
Hyperopia	5, 528
Myopia	1, 490
Presbyopia	578
Unclassified	22, 998
	44, 160

Diseases and injuries of eyeball and orbit.

Eyeball:	
anophthalmos (absence of eyeball)	12
buphthalmos	1
exophthalmos	40
glaucoma	54
injuries of—	
burns	1
contused	66
foreign bodies	14
lacerating	20
penetrating	27
rupture	14
unclassified	206
proptosis	5
tenonitis	3
Orbit:	
abscess	20
abcess, retrobulbar	1
angioma	1
cellulitis	45
cysts	14
emphysema	1
granulations	1
injuries of—	
contracted socket	28
foreign body	2
fracture	2
gunshot wounds	55
phlegmon	21
periostitis	1
sinus thrombosis	1
tumor	2
unclassified diseases and anomalies	25
	683

Tabulation of diseases of the eye—Continued.

Diseases and injuries of lacrymal apparatus.

Epiphora	90
Lacrymal canaliculus	1
foreign bodies—	
stricture	5
wounds	2
Lacrymal duct—	
stricture	169
Lacrymal gland—	
abscess	4
cyst	1
dacryoadenitis	3
hypertrophy	1

Diseases and injuries of lacrymal apparatus—Con.

Lacrymal sac—	
cyst	1
dacryocystitis	477
fistula	5
	759

Miscellaneous.

Miscellaneous diseases, and patients sent for functional examination	3, 142
Unclassified congenital anomalies	151
	3, 293

OPERATIONS.

Lid and brow.

Lids:	
abscess of, incision and drainage	210
adenoma, excision of	3
blepharoplasty	85
canthoplasty	1
canthotomy	4
chalazion, curettement	1, 220
chalazion, dissection	139
ectropion, operations	35
entropion operations	9
epilation of eyelashes	11
epithelioma, excision	3
fibroma, excision	2
foreign bodies removed	7
hematoma, incision and drainage	1
hordeola, incision and drainage	1, 020
milium, excision of	3
molluscum, excision of	1
papilloma, excision of	16
polyps, removal	1
ptosis, operations	10
tarsectomy	2
trichiasis, operations	4
tumor, excision of	6
unclassified operations	20
wounds, incised, sutured	8
wounds, lacerated, sutured	43
xanthoma, excision	2
Brow:	
tumor, excision	1
	2, 867

Lacrymal apparatus.

Accessory lacrymal glands, removed	1
Lacrymal canaliculus and punctum, dilated	21
Lacrymal canaliculus foreign body removed	1
Lacrymal canaliculus slit	14
Lacrymal duct probed	43
Lacrymal gland:	
extirpation of	3
abscess of, incised and drained	1
concretion of, excised	6
Lacrymal sac:	
extirpation of	44
incision and drainage	45
cysts of, removed	1
Unclassified operations	1
	181

Iris.

Iris:	
foreign body, removal	4
iridectomy	30
iridotomy	4
prolapse, excision	3
	41

Lens.

Lens:	
cataract, discission	2
cataract extraction	32
capsulotomy	4
dislocation, extraction	1
	39

Globe.

Globe:	
cysticercus of vitreous, attempted excision	1
enucleation	316
evisceration	11
foreign bodies in vitreous, magnet extraction	6
	334

Operations—Continued.

Orbit.

Orbit:	
abscess, incision	11
cellulitis, incision	17
foreign bodies, removal	3
granulations, excision	6
orbital implantations	3
plastic operations on	16
tumor, excision	1
unclassified	5
	62

Operations on ocular muscles.

Advancement external rectus	52
Advancement external rectus, Bridge's clamp tucking	1
Advancement external rectus, Todd's tendon tucking	12
Advancement internal rectus	7
Reese's operation	6
Tenotomy, external rectus	6
Tenotomy, internal rectus	218
	302

Conjunctiva.

Conjunctiva:	
angioma, excision of	1
cyst, excision	6
grattage	27
foreign bodies, removal	822
granuloma, excision of	3
melanosarcoma, excision of	1
peritomy	4
pterygium, excision of	16
pterygium, transplantation	488
trachoma, expression of	138

Conjunctiva—Continued.

Conjunctiva—Continued.	
tumor, excision of	3
wounds, incised, suture of	4
wounds, lacerated, suture of	14
	1,527

Caruncle.

Caruncle:	
abscess of, incision and drainage	3
encanthofibroma, excision of	1
	4

Cornea and sclera.

Cornea:	
abscess, incision of	1
calcareous deposit, excision	1
foreign bodies, removal	910
paracentesis	5
ulcer, conjunctival flap for	5
ulcer, cauterization	102
wounds of, conjunctival flap for	10
wounds of, and sclera, flap for	1
Sclera:	
cyst, hemorrhagic, excision	1
foreign bodies, removal	3
sclerotomy, posterior	2
tumor, excision	1
	1,043

Glaucoma.

Glaucoma:	
corneoscleral trephining	5
unclassified	7
	12

SUMMARY OF TOTALS.

Diseases and injuries:	
Eyelids and brow	8,256
Conjunctivitis and caruncle	30,416
Cornea and sclera	6,691
Uveal tract (iris, ciliary body, and choroid)	3,188
Lens	699
Vitreous	395
Retina and optic nerve	2,046
Extra and intraocular muscles	2,607
Orbit and eyeball	683
Lacrymal apparatus	759
Anomalies of refraction	44,160
Unclassified diseases and patients sent for functional examination	3,142
Unclassified congenital anomalies	151

Operations:	
Lid and brow	2,867
Lacrymal apparatus	181
Conjunctiva and caruncle	1,531
Cornea and sclera	1,043
Iris	41
Lens	39
Globe	334
Orbit	62
Ocular muscles	302
Corneoscleral trephining for glaucoma	5
Unclassified	7
Grand total	109,604

CHAPTER II.

GENERAL COMMENTS ON THE STATISTICAL TABLES.

DISEASES AND INJURIES.

EYELID AND BROW.

Among the 8,256 cases of eyelid diseases and injuries, blepharitis, chalazion, and hordeolum furnished the highest percentage, that of blepharitis being about the same as that which would exist in eye services in civil hospitals. The percentage of styes was somewhat higher in this respect and may have been due to the influence of the influenza epidemic in the fall and winter of 1918 and early part of 1919, exactly as this influence is probably responsible for the rather large number of lid abscesses (nontraumatic), both of the simple and phlegmonous type (36 cases.) (See also p. 577). Lid edema was common, traumatic and nontraumatic (168 cases), and lid abscess the result of a retained foreign body was observed. (Fig. 1.)

Including with the cases recorded as ectropion, those which are listed as cicatricial contractions of the lid, a total of 174 is reached, which would furnish a percentage much higher than would be found in civilian hospitals under ordinary conditions. This increase was due to the number of men with facial wounds who were evacuated from the American Expeditionary Forces to the eye services of this country.

No unusual diseases or deformities of the lids are reported, save only tuberculosis of the lid (ulcers); the diagnosis in these cases rested, however, on clinical and not on bacteriologic examination. Four cases of epithelioma of the eyelid are recorded; one had an unusual situation. (Fig. 2.)

Trichiasis and distichiasis, together making a total of 58 cases, were complications or sequels of trachoma in practically all of the cases and properly belong to the trachoma figures, except that they represent the chief condition for which the patients came for relief.

CONJUNCTIVA.

Ordinary catarrhal (simple) conjunctivitis and various types of contagious conjunctivitis (also called pink eye), totaling 21,776 cases, not only far exceed in number any other conjunctival disorder, but represent the greatest number of any of the ocular diseases recorded in the grand total.

Always exceedingly common affections, especially during the spring and summer months, their incidence was greatly increased during the period when influenza was epidemic, and is further commented on in a later paragraph.

Bacteriologic examination of the conjunctival secretions reported from the base hospital, Camp Taylor, shows that 25 per cent of the cases of acute conjunctivitis were due to the pneumococcus, Type IV appearing to be the predominant variety.

Among 258 bacteriologic examinations of conjunctival secretions from acute conjunctival inflammation, but not taken from a single hospital, the following organisms are listed in the order of their frequency:

Pneumococcus	191	Micrococcus catarrhalis	7
Staphylococcus	40	Xerosis bacillus	5
Streptococcus	13	Koch-Weeks bacillus	2

From the latter part of October, 1917, to the beginning of January, 1918, conjunctivitis in epidemic form was present in Camp Sherman.[1] This epidemic

FIG. 1.—Abscess of lid, due to retained foreign body.

FIG. 2.—Epithelioma of upper right lid.

was widespread, affecting over 1,200 men known to the authorities of the camp base hospital. Laboratory examination furnished the following results:

	Per cent.		Per cent.
Pneumococcus	37. 5	Morax-Axenfeld bacillus	3. 5
Staphylococcus (various types)	6. 0	Undetermined	9. 0
Meningococcus	1. 5	No organisms	40. 0
Koch-Weeks bacillus	2. 5		

The reporting officer's comment on the large number of negative cultures (40 per cent) is: "Painstaking laboratory experts were unable to find micro-organisms," and, although reaction was severe, the secretion and discharge from the conjunctival sac were limited in amount.

Although the report does not make the suggestion, it is possible that a certain number of these cases were varieties of provoked conjunctivitis where it is well known bacteriologic examination is usually negative.

From Camp Sevier [2] 741 cases of acute conjunctivitis were reported, including 400 which occurred during the prevalence of mumps and measles. The pneumococcus was the offending organism in a large percentage of the cases. Compared with the epidemic of conjunctivitis reported from Camp

Sherman (see above) the bacteriologic results were closely similar, save only that there were fewer negative cultures and that there was double the percentage of Koch-Weeks infections.

In the report from only one camp base hospital (Camp Grant), concerning itself with 210 cases of acute conjunctivitis bacteriologically examined, was the pneumococcus exceeded in frequency by any other organism. In this instance, and then only slightly, the staphylococcus (variety not listed), predominated (pneumococcus 19; staphylococcus 23). In 50 of the total examinations, however, the results were negative.

The infrequency of the Koch-Weeks bacillus in relation to the frequency of the pneumococcus as an etiologic factor in acute conjunctivitis, as recorded, would be noteworthy if the number of bacteriologic examinations had been larger; however, a well-known observation in civilian practice is confirmed, namely, that during the prevalence of acute conjunctivitis the pneumococcus may be more in evidence in one place and the Koch-Weeks bacillus in another. As a few cases of conjunctivitis (27) are listed as hemorrhagic, that is, acute varieties associated with conjunctival hemorrhages, and as this condition is common in Koch-Weeks conjunctivitis, it is probable that these types were produced by this organism.

The small number of cases of conjunctivitis attributed to the Morax-Axenfeld bacillus, only 14, gives, of course, no idea of the incidence of this microorganism as an etiologic factor in conjunctival inflammation; the figures are simply a record of definite findings in these 14 cases. The 2,865 cases of chronic conjunctivitis, including subacute varieties, would undoubtedly have furnished a large contingent of the Morax-Axenfeld variety. In one camp base hospital only (Camp Grant) the Morax-Axenfeld bacillus was noted as a factor in acute conjunctivitis and is credited with 2.5 per cent of the infections.

Among the cases noted as chemical, mechanical, and traumatic conjunctivitis belong the examples, less common in this country than in the American Expeditionary Forces, of provoked conjunctivitis; that is, conjunctival inflammation induced by soldiers and recruits to escape military service. The substances reported as provocative agents include carbolic acid, iodide of mercury, sulphate of copper, tobacco, soap, ordinary dirt, powdered ipecacuanha, and oil of cloves. The conjunctivitis provoked by the last-named substance was associated with membrane formation; bacteria were not present.

Solar conjunctivitis (photophthalmia) was noted in camps situated in the South. In one camp base hospital (Camp Johnston, Fla.) 70 men so afflicted reported on sick call. The conjunctival affection was caused in part by exposure to bright sunlight, but particularly to the glare from the white sand which was everywhere in evidence.

Thirty-nine cases of vernal conjunctivitis are included; in all instances probably exacerbations of the disease; that is, the affection was not acquired in the service. A few mixed cases were observed; that is, trachoma and vernal conjunctivitis.

The number of cases of pterygium, 1,126 in a total of 30,416 conjunctival affections, is not as high as might be anticipated, considering that many of the service men came from regions, for example, Texas and New Mexico, where this condition is exceedingly common. In fact, the percentage closely approximated that which is found in civilian eye hospitals.

The cases of conjunctivitis due to poisonous gas were in part found among men who prior to their return to eye centers in this country had been exposed in gas attacks, and partly among men at Edgewood Arsenal, Md., exposed for a period varying from 1 to 30 days to the air contaminated by the gas in the plant where the dichlorethylsulphide (mustard gas) was manufactured. The ophthalmologist at the station [3] has reported upon the ocular action of this gas, finding cases which, in their conjunctival manifestations, ranged in severity from a mild conjunctivitis with slight lacrymation and photophobia and only slight injection of the conjunctivæ, radiating from the limbus in a triangle and toward the inner and outer canthi and the middle of the palpebral fissure, with a pearly white conjunctiva above and below, to high-grade conjunctivitis associated with edema of the lids and chemosis.

In seven cases hemorrhages in the ocular conjunctiva were noted; profuse lacrymation was common; mucopurulent secretion was rare. Corneal complications are not recorded in the report. The earlier cases remained in the hospital from 3 to 6 weeks; later cases from 7 to 14 days.

The treatment recommended was one cocaine instillation, atropine to keep pupil dilated, boric acid flushing, dusting with powdered iodoform, and applications of yellow oxide of mercury to eyelid; eye bandages from three to seven days. Styes, chalazia, and small lid abscesses were noted as complications.

In the American Expeditionary Forces during warfare activities the most satisfactory collyrium was a 1 per cent solution of bicarbonate of soda. Bandaging of the eyes was considered detrimental, in that it led to secondary infections. In experimental mustard-gas conjunctivitis a 1 per cent solution of dichloramine-T in chlorcosane was recommended as a lotion (Warthin).[4]

Although no corneal complications were observed among the men afflicted in Edgewood Arsenal, such complications were noted among men returned from abroad; for example, recurring keratoconjunctivitis of great severity (three attacks)[5]; ulcerative keratitis followed by deep parenchymatous infiltrate and pannus; also staphyloma, bilateral.

Fundus lesions attributed to the influence of mustard gas were uncommon. One case of choroiditis (the man had also extensive skin lesions) and one case of optic nerve atrophy were recorded.

There were 419 cases of phlyctenular conjunctivitis and 146 cases of phlyctenular keratitis. The total number of cases of phlyctenular keratoconjunctivitis (565), while not exceeding the proportion ordinarily found in civil hospital practice, which includes all ages and especially many patients before the age of puberty, is beyond the total which would be normal among patients whose ages range from 20 to 45 years.

The frequency of phlyctenular disease among soldiers in camps and camp hospitals is commented upon by a number of medical officers and the suggestion made that indiscretions in diet, and especially an unusual consumption of sugars in the form of candy, may have been an etiologic factor. in that it induced gastrointestinal fermentation.

Chronic ethmoiditis is also suggested as a cause, but this relationship in adult phlyctenular disease is not so well established as it is in the children and juvenile forms of the disease.

TRACHOMA.

From 17 of the eye services of the hospitals listed no cases of trachoma are reported. From the remainder 1,749 cases are recorded, and if to these are added the cases of pannus, trichiasis, and xerophthalmos, separately catalogued, but none the less sequels or complications of the disease, the total number would be 1,818.

These cases of trachoma appeared on the records of the hospitals and do not include those found, for instance, during camp inspections or during the examination of recruits, unless the soldier or recruit had been sent to the camp hospital. Thus in the wards and out-patient department of the base hospital of Camp Zachary Taylor 238 cases of trachoma were received and are recorded, but well over 1,000 cases of this disease were discovered by examining officers in various parts of the camp. Most of these subjects of trachoma were rejected or discharged as soon as discovered. The large number of cases of trachoma found in this camp was due to the fact that the first troops were drawn almost entirely from southern Indiana, southern Illinois, and Kentucky, regions where this disease is prevalent.

Of the 41 hospital services reporting trachoma, in only 3 did the number of cases exceed 100, namely, Base Hospital, Camp Taylor, Ky., 238; Base Hospital, Camp Cody, N. Mex., 191; and Base Hospital, Camp Greene, N. C., 114, the last two being also camps where many soldiers coming from trachoma regions were stationed:[a] in 10 the number of cases ranged from 30 to 76, and in 28 the number of cases ranged from 1 to 24.

An observation made by the ophthalmological staff at Camp Taylor is important; namely, that among the thousands of southern negro troops stationed at this camp not one case of trachoma had come to the attention of this staff. In one hospital (General Hospital No. 11, Cape May) the case of a negro with trachomatous pannus is recorded. Camp Gordon reports that when troops were drawn from regions in which trachoma is not prevalent very few cases came under observation.

In the earlier period of the war, except for a brief time, trachoma cases were rejected; later men in the service who had or had acquired trachoma were received for treatment in the base hospital and if not cured within a specified time were discharged.[b] Hence opportunities for observation of the effects of various procedures, mechanical and medicinal, were afforded.

From Camp Taylor about 20 men were sent, by permission of the Surgeon General, to the United States Marine Hospital, Louisville, Ky.,[6] and submitted to the method of operating employed by the United States Public Health Service, a form of brossage.[7] The hospitalization of these men varied from a few days to several months. The final record shows that 16 were returned to full duty: the remainder, while harmless as to the liability of infecting others, were still unfit for military duty.

In general terms, the operation employed for the relief of trachoma was that known as expression (performed with Knapp or other suitable forceps):

[a] In addition to the regions named trachoma is prevalent in the neighborhood of the junction of Kentucky, Tennessee, and the Virginias; also in Texas, Arizona, and New Mexico.

[b] For a full account of the management of the trachoma problem see administrative history of the Section of Ophthalmology, Surgeon General's Office, Volume I, Medical Department of the United States Army in the World War, pp. 443 and 444.

138 such operations are noted in the hospital records; other surgical methods, for instance, excisions of the retrotarsal folds, were rarely employed; e. g., tarsectomy operations.

On the suggestion of Dr. Brown Pusey,[6] transmitted through the Surgeon General's Office to Base Hospital, Camp Taylor, the internal administration of iodide of potassium was used during periods of exacerbation of trachoma. Of 10 patients thus treated whose condition had been reported by the officer in charge of the ophthalmic service[6] in 5 there was rapid cessation of the symptoms within 48 hours; the others failed to respond to the treatment. In place of the ordinary collyria and antiseptics a one-half per cent oily solution of dichloramine–T received recommendation as a useful agent to control abnormal secretion.

Trachoma treated with submucous injections of dichloramine–T in Base Hospital, Camp Beauregard, resulted in permanent thickening of the lids.[8] But favorable results were noted in Base Hospital, Camp McClellan, under the influence of sulphate of copper and dichloramine–T. In Base Hospital, Camp Dodge, massage with 1:500 bichloride gauze, followed by castor oil, was utilized with satisfaction.

The so-called *bacillus bulgaricus* treatment of tracnoma was used in Base Hospital, Camp Sevier, S. C. (seven chronic and two acute cases). The conclusion was reached that the method was detrimental in the presence of acute symptoms and of no valuable influence in the chronic types.[2]

A form of subacute conjunctivitis resembling trachoma was noted[9] among men engaged in currying horses, due to the conveyance of the dirt and dandruff from the animal to the affected eye. In the secretion there was abundance of eosinophiles. This observation confirmed others which had been made abroad.

Trachoma, always a menace in Army life, proved to be far less formidable than had been anticipated, and even in those camps where many cases were discovered the methods employed for their elimination and care prevented the development of an epidemic.

GONORRHEAL CONJUNCTIVITIS.

One hundred and seventeen cases of gonorrheal conjunctivitis are reported from 30 of the hospital services listed; from 20 of the services it is definitely stated that no cases of this affection had occurred. Three cases are recorded as bilateral, four as unilateral; no exact mention is made whether this disease was unilateral or bilateral in the remainder, but it may be inferred that in the majority the infection was unilateral. The greatest number of cases which occurred in any one hospital was 9 (Base Hospital, Camp Bowie); in 16 hospitals the numbers recorded are from 3 to 7; in the remainder, 1 to 2. The results are reported as follows:

	Cases.		Cases.
Complete recovery	81	Both eyes lost[a]	2
Recovery with resulting leucoma or nebula.	6	Result not stated	20
One eye lost	8		

CORNEA.

Special attention is drawn to ammonia burns of lids, conjunctiva, and cornea (201 cases of burns of these tissues from all causes are recorded in the

[a] One patient died from an intercurrent bronchopneumonia.

statistical tables) in a report from camp hospital, Camp Grant, Ill.,[10] caused by the ammonia solution used in the mixture for cleaning rifle bores. The accidents occurred because of a splash of the liquid ammonia as the rubber stoppers of the glass bottles containing the fluid were removed. Usually the lower conjunctival and corneal areas were affected: grayish-white infiltrates, followed by sloughing of the tissue, were noted; false pterygia and symblephara, and in some cases perforation of the cornea and prolapse of the iris are recorded as sequels.

Six hundred and fifty infected (sloughing) ulcers of the cornea were reported from the various hospital services and 29 cases in which there was a combination of the corneal ulcers with pus in the anterior chamber, therefore hypopyon keratitis. The results of bacteriologic examinations, if made, are not included in the records.

Nine cases of corneal disease are definitely classified as keratitis disciformis, with gray disc-like central lesions, overlaid by smooth cornea. In one case reported from Base Hospital, Camp Sevier, an uncommon complication arose, namely, perforation of the cornea followed by iridocyclitis; the patient also had constitutional syphilis. The ultimate result after the subsidence of the affection was a permanent disc-like central corneal opacity.

UVEAL TRACT.

The difficulty of definitely classifying inflammations of the uveal tract from the etiologic standpoint is evident in the statistical tables where, for example, 848 cases of iritis, 132 cases of iridocyclitis, 47 cases of uveitis, and 544 cases of choroiditis are listed as such; that is, without reference to the cause.

With regard to the activity of the process the results are as follows: Acute iritis, 262 cases; acute choroiditis, 4; chronic iritis, 18; chronic uveitis, 3. Those cases listed as posterior synechiæ (71 cases) refer to sequels of former iritis found in routine ocular examinations.

Of the cases of choroiditis reported according to the clinical manifestations, that is, disseminated, diffuse, etc., the exudative varieties furnished the largest contingent and evidently included such as ordinarily are classified as plastic or circumscribed plastic in civilian practice.

One defect in the records from the statistical standpoint is that they relate only to cases selected from a population constantly changing. Hence they can not be used to determine the frequency of any one ocular disease in the Army in general. They have some value in determining the frequency of the causes of certain eye disease. When, however, an attempt was made to obtain an idea of the relative frequency of the causes of iritis, for example, by tabulating the possible etiologic factors in each case, a great difficulty was encountered in isolating the actual cause in a given case where several possible causes were present.

Thus in 14 cases of iritis carefully examined from this standpoint, the results were as follows:[11]

Gonorrhea	1	Gonorrhea, syphilis	5
Syphilis	1	Mumps, rheumatism	1
Gonorrhea and infected tonsils	1	Infected tonsils, rheumatism	1
Gonorrhea, dental abscess, rheumatism	1	Trauma	2
Gonorrhea, syphilis, mumps, and rheumatism	1		

The reports from many hospital services indicate the frequency of focal infections as a cause of uveal tract diseases, especially iritis and iridocyclitis, and also exudative (plastic) choroiditis. The cause of the infection was most often found in the teeth (apical abscesses), next in the tonsils and also in the sinuses, usually the ethmoid. In one service (Base Hospital, Fort Riley) cases of mild iritis were frequent, traced to infected teeth (on the same side as the iritis) the removal of which determined a rapid subsidence of the inflammation.

The large number of injuries pertaining to the uveal tract, that is, rupture of the choroid (38 cases), combined rupture of the choroid and retina (29 cases), traumatic choroiditis (25 cases), traumatic iritis (18 cases) and iridodialysis (52 cases) are accounted for by the fact that among them are included the results of contusion and concussion injuries of the globe which notably increased when soldiers from overseas arrived, and were placed in the various hospitals, especially those designated as eye centers.

CRYSTALLINE LENS AND VITREOUS.

The records of anterior polar cataract (28 cases) evidently include both congenital and acquired varieties; that is, of the anterior type, pyramidal lesions due to capsular opacity and circumscribed deposits caused by perforating corneal ulcers in earlier life. The posterior variety (23 cases) doubtless includes not only small opacities on the posterior capsule due to vestigial remains of the hyaloid artery, of which in a persistent form 10 cases are recorded, but also those lesions which may have accompanied high myopia, choroiditis or pigmentary degeneration of the retina, and which really were posterior cortical cataracts. It may be that the capsular cataracts listed (15 cases) belonged to one or the other of these types; the records are not explicit.

The small number of senile cataracts of a mature character would be remarkable in so large a collection of ocular disorders (more than 100,000 cases) save only that in the great majority of the eye examinations the age of the patients was under 45 years.

Ordinarily 244 cases of traumatic cataract in a total of 692 cases of lenticular disorders would be a large proportion, but they include the records of soldiers returned from overseas among whom lens traumatism was not uncommon. This fact also accounts for some of the cases of dislocation of the lens (24 cases). A rare variety of cataract is the so-called *cataracta cærulea*, of which one example is recorded. Special mention of one case of lenticonus is made elsewhere (see p. 615).

RETINA AND OPTIC NERVE.

The influence of injuries sustained overseas is evident in the list of traumatisms of the retina, including rupture (11 cases), commotio retinæ (2 cases), traumatic perforation of the retina, that is, so-called holes in the macula (8 cases), detachment of the retina (a definite proportion, 85 cases, probably were traumatic), and retinitis proliferans, or, more properly, chorioretinitis proliferans (21 cases) as sequels of concussion and contusion injuries of the globe.

Doubtless some of the cases classified simply as retinitis (338 cases) or retinochoroiditis, belonged to the traumatic group, but the records are not definite in this respect.

Nyctalopia refers to that condition ordinarily described as night-blindness without ophthalmoscopically evident pigmentation (27 cases), a condition frequently noted overseas, where those affected were known as nocturnal amblyopes. The determining causes were great fatigue, unsatisfactory diet, exhaustion from loss of blood, and refractive error. Where actual pigmentation in the retina was discoverable the cases are listed as retinitis pigmentosa (102 cases). The cases described and recorded as Gunn's dots, 11 in number, almost certainly indicate small, light-colored or glistening granules in or near the macula without pathologic significance, and should not be considered as true Gunn's dots, which have a different distribution and may be regarded as a clinical entity. This is not an uncommon mistake in diagnosis.

Most of the cases classified as choked disc and optic neuritis were probably due to meningitis or to acute infections complicated with meningeal lesions. When assigned to special causes, except as stated, choked discs are definitely recorded in relation to intracranial lesions as follows: Meningitis (6 cases), brain abscess (1 case), gumma of the brain (1 case), injury (1 case), cerebellopontine cyst (1 case), brain tumor (3 cases). A number of cases of choked disc discovered in soldiers coming from overseas were noted as the result of head injuries.

The group of cases (121 in number) noted as pseudoneuritis, while it contains some instances of so-called hyperopic disc, that is, a disc-hyperemia with blurred edges due to refractive error, includes in largest measure, as the records indicate, cases of mild neuritis, which were noted during the examination of patients suffering from acute infections (influenza) and from meningitis, or at least meningeal irritation. For further discussion of disc changes (neuritis and papilledema), see pages 578 and 579.

The cases of optic nerve atrophy (407 in number) were due to injury, syphilis, to various toxemias, and also include those which were consecutive to optic neuritis or papilledema. The records, however, are not complete enough to make a numerical assignment in each instance.

EXTERIOR AND INTERIOR OCULAR MUSCLES.

The 417 cases of heterophoria (13 unclassified) do not, of course, comprise the total number of examples of muscle imbalance, but only those which were definitely named and classified. Even so, the preponderance of esophoria (as measured at the distant point) is evident, as usually is the case in estimations of this character.

Noting the relative frequency of paralysis of the exterior ocular muscles the records yielded the following results: Paralysis of the external rectus, 38; of the oculomotor (third pair), 22; of the internal rectus, 6; of the inferior oblique, 5; of the superior rectus, 3; of the superior oblique, 2; no isolated cases of palsy of the inferior rectus are reported. The relative frequency of these palsies of the ocular muscles corresponds with that usually, but not invariably, given in statistics from civilian hospitals only in so far as the external rectus and oculomotor (third pair) are concerned; but differs with respect to the relative frequency of the remainder, their order usually being, after the first two named, superior oblique, inferior rectus, superior rectus and inferior oblique. Had the unclassified palsies (28 in number) been identified the ratio frequency might have been different.

The association of abducens and facial palsy was observed in connection with mastoid disease. The etiologic factors noted in relation to the ocular muscle palsies, both external and internal, were syphilis, acute infections, especially influenza, encephalitis, sinus affections, orbital cellulitis and injury; but the records are not sufficiently complete to estimate the relative frequency of these factors, except that syphilis was the preponderating cause (see also pages 575 to 577), which infection probably accounts for the rather large number of cases recorded simply as ptosis.

ANOMALIES OF REFRACTION.

It was the rule in the Army hospitals and services to utilize mydriatics (usually homatropine, rarely atropine) in the estimation of errors of refraction, save only in cases of presbyopia and when manifest corrections were occasionally ordered because of lack of time to do otherwise. The work was of high order. Retinoscopy was in general use. The ophthalmometer was employed in some of the services, but not to the exclusion of other methods of testing corneal astigmatism. The objective determinations were followed by the usual subjective tests (trial case, astigmatic chart, etc.), and in some services a post-cycloplegic examination was made. In a few of the services a drop of a myotic solution (pilocarpine hydrochloride) was instilled at the conclusion of the tests in order to shorten the period of mydriatic disability.

Only one instance of poisoning following the use of a cycloplegic is recorded, viz., from Base Hospital, Camp Sherman. The patient, a private soldier, aged 28, after the instillation of the second drop of a homatropine-cocaine solution (2 per cent was the usual strength used in the clinic) became flushed, delirious, and in general terms developed the symptoms of atropine poisoning. These manifestations lasted only one day, and at the end of that period recovery was perfect and there were no untoward sequels.

The total number of anomalies of refraction recorded in the statistical tables is 44,160. Of these, however, 22,998 are unclassified in the sense that the exact character of the refractive error is not stated and 74 of them are listed as refractive amblyopia, indicating evidently various types of astigmatic amblyopia and amblyopia from disuse (amblyopia exanopsia) in patients with concomitant squint. Excluding these, there remain 21,074 cases carefully classified as follows:

Emmetropia	5	Compound myopic astigmia	1,525
Simple hyperopia	5,528	Mixed astigmia	1,620
Simple hyperopic astigmia	1,653	Anisometropia	129
Compound hyperopic astigmia	6,987	Presbyopia	578
Simple myopia	1,490		
Simple myopic astigmia	1,559		21,074

As the determinations followed the use of a cycloplegic in practically all of these cases (presbyopia excluded) and as the subjects ranged in age from 19 to about 40 years, they furnish a confirmation of the well-known infrequency of emmetropia in properly examined eyes.

The usual preponderance of hyperopic refraction is evident; that is, hyperopia and hyperopic astigmatism, as compared with myopia and myopic astigmatism. The small number of presbyopes is accounted for in that compara-

45267°—24——37

tively few patients beyond the military age reported in the clinics; they were chiefly senior officers and men who were in domestic service.

For comparison, an analysis of one thousand most carefully determined errors of refraction recorded in the Attending Surgeon's Office, Washington, D. C.,[12] are quoted:

	Per cent.		Per cent.
Emmetropia	0.5	Simple myopia	3.5
Simple hyperopia	8.5	Simple myopic astigmia	3.3
Simple hyperopic astigmia	5.7	Compound myopic astigmia	16.9
Compound hyperopic astigmia	45.8	Mixed astigmia	15.8

The above list may be compared with the tabulation in Base Hospital, Camp Sevier,[2] of 837 cases of refractive error, all determined with the aid of a mydriatic (homatropine or atropine):

	Per cent.		Per cent.
Simple hyperopia	14.0	Simple myopic astigmia	3.0
Simple hyperopic astigmia	10.0	Compound myopic astigmia	6.0
Compound hyperopic astigmia	53.0	Mixed astigmatism	11.0
Simple myopia	3.0		

EYEBALL AND ORBIT.

The rather large number of cases of exophthalmos (exopthhalmos 40, proptosis 5), evidently a symptom diagnosis, are not reported with sufficient definiteness to develop the etiologic factor. A few refer to exophthalmic goiter, but the majority were evidently symptomatic of orbital cellulitis and sinus disease, especially ethmoiditis.

Glaucoma (classified with the diseases of the eyeball) was noted in 54 cases, but no attempt was made to separate primary from the secondary varieties; in a few instances injury determined a rise of intraocular pressure. One case of bilateral juvenile chronic glaucoma was observed, the soldier having been returned to this country from the American Expeditionary Forces.

The 12 cases listed as anopthalmos refer to patients who reported in various eye services after an enucleation of an eyeball elsewhere performed. They were not of the group (28 in number) requiring operative treatment to permit insertion of an artificial eye and described as contracted sockets.

Of the 65 cases of orbital cellulitis, 20 are reported as abscess of the orbit; that is, a cellulitis which eventuated in suppuration in some portion of the cellulo-fatty tissue of the orbit (many of them complications of sinus disease), while the remaining 45 cases appear to have undergone resolution, in that no pus formation occurred.

It is not quite clear from the diagnostic tabulation what the situation of the lesion was in the twenty-one cases of phlegmon of the orbit, but probably in the majority of the instances it was not a localized or general suppuration of the orbital contents, but an abscess which existed in close association with the orbit; for example, in or beneath the tissue of the brow or orbital margins.

The majority of orbital gunshot injuries (55 in number) referred to soldiers wounded in France who on their return were sent to the various eye centers in this country.

Many recruits and soldiers were sent to the eye services of the various hospitals to ascertain whether the symptoms presented were of ocular origin

or not and to determine whether their visual acuteness conformed with the required standard; hence the group of miscellaneous diseases and patients sent for functional examination (3,142 cases).

A few observations of soldiers included in this group are of special interest. Thus an investigation from the ocular standpoint reported from United States General Hospital No. 9, Lakewood, N. J.,[13] showed that the visual fields (white and colors) of all men who were the subjects of functional heart disease were concentrically contracted, the more pronounced the functional disorder the greater the contraction. In other words, the visual field phenomena were similar to those which are not unusually associated with neurasthenia.

All gassed men entered in United States General Hospital No. 12, Biltmore, N. C. (number not stated),[14] were carefully examined with the ophthalmoscope; those who had been exposed to mustard gas exhibited only such superficial manifestations as would be produced by any other irritant, but no fundus lesions; those who had been exposed to chlorine gas showed engorged retinal vessels and congestion of the optic nerve heads; those who had come in contact with phosgene gas, only hyperemia of the optic disc, while those who had encountered mixed gas had eye-ground lesions identical with those produced by chlorine gas. One case of choroiditis attributed to the influence of gas and one of optic nerve atrophy are reported, the former from General Hospital No. 7 and the second from Camp Sevier.

To this group also belong a number of men suspected of ocular malingering; but the tabulations are not sufficiently accurate to formulate a statement of the exact number of individuals in this class. In one base hospital (Camp Sevier, S. C.) the following classification was adopted: Those who deliberately manufactured their complaint, that is, there was no basis for it; and those who, often from fear, exaggerated minor defects or symptoms. The detection of ocular malingering offered no special difficulties, the usual tests being effectual.[15]

OPERATIONS.

Including such minor procedures as removal of foreign bodies (conjunctiva and cornea), excision or curettement of chalazia, incision of abscesses and styes, 6,400 operations are reported. According to a rule generally enforced, operations were limited to those required by injuries, by acute processes, or by conditions the surgical relief of which would improve the soldiers' efficiency; hence, the number of major ocular operations was comparatively small, a number, however, which increased after soldiers who had been wounded in France began to arrive in this country. These operations were for the most part concerned with various plastic and blepharoplastic procedures which are elsewhere described (p. 616). A considerable number of operations of this type are not included in the tabulation because the wounded men were the subjects of extensive facial injuries, including the eyelids, and therefore were referred to the department of plastic surgery (see section on maxillofacial surgery), and because a certain percentage of wounded men arrived after the work of a number of the eye services of various hospitals listed had been discontinued and were sent to hospitals whose records are not included in the present tabulation.

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CHAPTER III.

SPECIAL REPORTS.

OCULAR SYPHILITIC MANIFESTATIONS.

In several hospitals, in order to determine the incidence of ocular complications among syphilitics, a routine examination was made of the subjects of lues confined to the wards. The results of one such tabular statement follow: [1]

Ocular examination of 117 syphilitics, United States General Hospital No. 14.

Angiosclerosis of retina, secondary stage	1
Atrophy of retina (localized), tertiary stage	1
Chorioretinitis, tertiary stage	1
Iritis, recurrent:	
Secondary stage	2
Tertiary stage	2
Keratitis interstitial, hereditary lues	2
Neuritis, optic, secondary stage	2
Neuroretinitis (low grade):	
Primary stage	1
Secondary stage	11
Tertiary stage	1
Neuroretinitis (well marked), secondary stage	2
Optic atrophy (primary), tertiary stage	2
Preretinal hemorrhage	1
Retinal hemorrhages, secondary stage	2
Retinitis, hemorrhagic, secondary stage	1
Cases showing no eye condition:	
Primary stage	19
Secondary stage	48
Tertiary stage	12

A survey of 460 cases of syphilis from ward No. 13, Base Hospital, Camp Lewis,[2] yielded comparatively few instances of ocular lesions traceable to lues: 7 cases of external ocular muscle palsy (muscles involved not stated); 3 cases of retinitis pigmentosa; 2 cases of choroiditis; 1 case of proliferating retinitis, and 14 cases of neuritis and retinitis. The nerve-head lesions disappeared under treatment with complete restoration of vision in all of the patients except two with marked papillitis.

A survey of the records of the various hospitals (eye services) where the reports state that syphilis as an etiologic factor in the ocular lesion was definitely determined yields the following results:

Eyelid:	
Tarsitis	1
Ulcer, marginal	1
Cornea:	
Keratitis (type not noted)	3
Keratitis, interstitial	53
Uveal tract:	
Gumma, ciliary body	1
Iritis and iridocyclitis	110
Iritis, chronic	11
Iritis, papulosa	7
Iridoscleritis	3
Uveal tract—Continued.	
Uveitis and hyalitis	7
Choroiditis	53
Chorioretinitis	12
Optic nerve and retina:	
Optic neuritis and choked disc	14
Optic nerve atrophy	23
Retinitis	58
Muscles: Palsy of external muscles	8
Total	358

The greater frequency with which the uveal tract accepts luetic infection is evident from this tabulation, which, however, can not possibly represent the total number, as many of the cases listed simply as iritis and choroiditis, must have been of syphilitic origin. These figures simply represent those cases which are recorded as syphilitic.

The frequency with which syphilis was found to be the cause of iritis or iridocyclitis varied from 33 per cent (Base Hospital, Camp Pike) to 75 per cent (Base Hospital, Camp Kearny), corresponding in this particular fairly closely with well-known statistics—for instance, those of Alexander, where a percentage from 30 to 60 is recorded.

A higher percentage of the ocular manifestations of syphilis was found among negro than among white soldiers. Definite record of this observation is made in the reports from the base hospitals of Camp Taylor, Camp Dix, and Camp Gordon.

How many of the cases of interstitial keratitis were due to inherited and how many to acquired syphilis could not be determined from the records; the inherited type of the disease undoubtedly preponderated. Many of the cases were acute, but in a certain proportion of them corneal lesions evidently had been acquired before the soldier's enlistment.

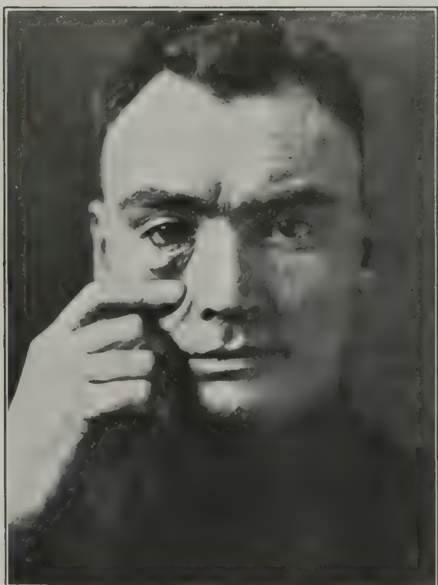

FIG. 3.—Syphilitic ulcer of lid; tertiary lesion.

Exclusive of those listed as unclassified the general statistical table records 102 cases of palsy of the exterior ocular muscles, but only 8 are attributed to syphilis in the above tabulations, a number far below the proportion which must have actually existed, even though, as is elsewhere stated, acute infections, notably in the influenza epidemic, furnished an unusually large contingent.

Except in one record, already quoted (p. 575), the diagnostic tables have failed to attempt a differentiation of the types as syphilitic choroiditis and chorioretinitis. It is evident that a certain proportion of the cases of luetic choroiditis were discovered in routine examinations, having existed prior to the patient's period of enlistment, and were not acquired after military service began. For the most part there is no statement with respect to the clinical types of retinitis, which are grouped under one general term, save only one case of central relapsing retinitis (a rare form) and one case of angiosclerotic retinitis (luetic endarteritis) also an unusual variety. Papilloretinitis, as distinct from retinitis, is reported from United States General Hospital No. 6, Fort McPherson, Ga. (21 cases).

The marginal lid ulcers reported from Base Hospital, Camp Sherman, and United States General Hospital No. 2, were tertiary lesions; the period at which the single case of tarsitis (a comparatively rare manifestation) occurred is not recorded.

An attempt was made in a few instances to determine the exact incidence of syphilis among all the patients who presented themselves at various hospital eye services. Thus, among 830 patients observed and examined in the eye

department of Base Hospital, Camp Sevier, 36 had syphilis, and of these 14 exhibited ocular lesions: optic neuritis, 4 cases; choroiditis, 3 cases; neuroretinitis, 7 cases; iritis, 2 cases; keratitis, 1 case; reflex iridoplegia, 2 cases.[3]

That iritis, interstitial keratitis, and optic neuritis may develop in syphilitic subjects while they are under treatment is well known and receives confirmation from several reports. Thus, Base Hospital, Camp Lee,[4] records the case histories of 3 patients who developed optic neuritis from 1 to 3 months after their last intravenous injection of arsphenamine; in one case after 4 injections, and in another after 6 injections. An identical experience is recorded from United States General Hospital No. 26, Des Moines; that is, one of optic neuritis. A syphilitic patient in Base Hospital, Camp Devens,[5] six weeks after the sixth injection of arsphenamine, developed iritis typically luetic in character, although the blood Wassermann reaction was at the time negative. Recovery under the influence of mercury is recorded.

A careful investigation of patients who had received injections of arsphenamine[2] failed to discover, in any instance, permanent ocular lesion—that is, optic nerve atrophy (one patient had received during several years twenty-seven injections)—although inflammation of the nerve-head was observed following injections of this drug.

OCULAR COMPLICATIONS DURING INFLUENZA EPIDEMIC.

During the prevalence of influenza (1918 and 1919) many ocular complications occurred. Lid edema and eyelid abscess were common; occasionally a few cases of blepharitis. By far the most frequent complicating ocular disease (special records from 25 camps) was conjunctivitis, which was exceedingly common and varied in severity from the moderate catarrhal types to those with abundant mucopurulent and purulent secretion, occasionally associated with corneal involvement. Almost without exception the predominating microorganism found in the secretion was the pneumococcus (50 per cent of the cases, Camp McClellan); comparatively rarely the influenza bacillus was detected, and this is a matter of comment in a number of the reports. One exception to this rule occurs in the bacteriologic examinations of a consecutive series of cases of conjunctivitis associated with influenza in Camp MacArthur.[6] They are listed as follows:

Bacillus of influenza	53	Pneumococcus	52
Bacillus of Hoffmann	19	Staphylococcus albus	41
Bacillus of Morax-Axenfeld	28	Staphylococcus aureus	11
Bacillus xerosis	10	Streptococcus	5
Diphtheroids	8	Tetramicrococcus	10

The laboratory also reported the detection of an organism somewhat resembling the gonococcus in a number of cases of conjunctivitis which developed during this period, probably the micrococcus catarrhalis.

No ocular lesion attributed to the streptococcus hemolyticus was observed in any of the hospital services, except one case of ulcerated blepharitis, where this organism was discovered (Base Hospital, Camp Grant).

A successful treatment of the types of conjunctivitis due to pneumococcus and influenza bacillus consisted in the instillation once or twice daily of a half of one per cent solution of ethylhydrocupreine.[6] The average period of treat-

ment was one week; a few relapses and reinfections occurred which yielded promptly to a renewal of the medication.

Corneal complications, with or without conjunctivitis, were common, practically always in the form of herpes of the cornea (herpetic keratitis); only five cases are recorded where the ulceration did not conform to this type of keratitis.

Acute iritis as a complicating factor during the attack was noted in a few instances (four cases); but as a sequel was observed more frequently, probably, however, the outcome of a remaining focal infection; for example, in the sinuses or tonsils. Muscle defects were observed as follows: Complete paralysis of the ciliary muscle three times; paresis of accommodation, frequently; and paralysis of the exterior ocular muscles (number of cases not stated). In five instances the abducens is definitely mentioned as the nerve involved, attributed to the action of the influenza toxin; in one case influenzal meningitis was present.

Optic neuritis (papillitis) is reported five times; one of the patients had an influenzal pneumonia. Secondary optic nerve atrophy was observed once, probably the result of a primary retrobulbar neuritis.

Orbital cellulitis was noted independently of sinus infection during an influenzal attack, but only once reported as a definite nonsuppurative type.

Metastatic ophthalmitis was observed in a few instances, recorded as choroidal abscess (Base Hospital, Fort Riley); panophthalmitis (Base Hospital, Camp Taylor), the patient also having thoracic empyema, and the same organism was present in the pleural fluid and the pus of the inflamed eye; suppurative iridochoroiditis (Base Hospital, Camp Beauregard) associated with empyema and influenzal pneumonia; and metastases to globe, further complications being pneumonia, meningitis, and an abscess of the knee.

In Base Hospital, Camp Travis,[7] from one to two weeks following the influenza epidemic, several patients reported to the eye service because of sudden reduction of vision (20/100 each eye); ophthalmoscopic examination was negative; all except one man recovered without treatment. Granting the absence of malingering, which was suspected but not detected, the cases appear to have been a form of post-influenzal amblyopia, possibly an attenuated form of retrobulbar neuritis. The soldier who did not recover, although there were no demonstrable ophthalmoscopic lesions, had a central relative scotoma in each field; serological tests were negative. This was probably a case of influenzal neuritis; the condition of the paranasal sinuses is not recorded.

OCULAR COMPLICATIONS IN MENINGITIS.

A moderate optic neuritis in meningitis was commonly observed and is especially commented upon in the reports of the eye services of the base hospitals of four camps (Meade, Hancock, Kearny, Beauregard). In Camp Meade[8] up to March, 1919, 66 ophthalmoscopic examinations made in 83 cases of epidemic cerebrospinal meningitis revealed a normal fundus in the earlier period of the attack, but as the disease developed a moderate type of optic neuritis appeared, which gradually subsided as the case progressed to recovery. All patients were treated intraspinally with antimeningococcus serum. Eleven cases of optic neuritis are reported without statement as to the severity of the lesion, while in 10 instances (6 in one base hospital, Fort Sill) the nerve-head

changes assumed the appearances of choked disc, all of the cases being of the pneumococcic variety. Retrobulbar neuritis was observed in one base hospital (Camp Merritt) and three cases of optic nerve atrophy (probably consecutive) are recorded (Camp Gordon). Two cases of metastatic ophthalmitis were noted, one bilateral (base hospital, Camp Lee) and one case of double iridochoroiditis with cataract formation (Base Hospital, Camp Hancock). A few cases only of exterior muscle palsies were investigated, the nerve most often affected being the abducens.

OCULAR COMPLICATIONS IN ACCESSORY SINUS INFECTIONS.

Because paranasal sinus infections were not infrequently the sequels of influenza (sometimes a coexisting affection) it is not possible to state with accuracy the frequency of ocular complications in each condition.

Of the minor disorders of the eye and its annexa, lid edema, styes, blepharitis, conjunctival hyperemia, and chemosis, moderate conjunctivitis and retinal congestion were frequently observed, confirming in this respect observations in civilian practice. Special mention is made of persistent asthenopia as a result of sinusitis.

Superficial keratitis was noted, attributed to ethmoiditis in all of the cases, except one of pansinusitis. These corneal lesions appear not to have belonged to any of the types of herpetic keratitis which occurred with comparative frequency in association with influenza.

A few cases of iritis and iridocyclitis (one typical uveitis) developed as the result of ethmoiditis or general accessory sinus infection.

Of the major intraocular disorders choroiditis, chorioretinitis, optic neuritis, and optic nerve atrophy were observed. Of the cases, four in number, of choroiditis all were found to be in association with ethmoiditis.

The cases of optic neuritis (papillitis) caused by sinus infection were due to ethmoiditis, except a few (number not stated) reported from Base Hospital, Camp Shelby, which were attributed to frontal sinusitis and one to sphenoiditis. One patient (recorded in Base Hospital, Fort Riley) had, in addition to papillitis, orbital cellulitis from maxillary sinusitis; recovery was prompt.

Orbital cellulitis, both the suppurating and nonsuppurating types, became a complication of sinusitis in a number of cases and was observed in frontal sinusitis (several cases); maxillary sinusitis (one case); and ethmoiditis (nine cases exactly reported, but also other cases without statement of the number). In the Base Hospital, Camp Dodge, two cases of bilateral suppurative orbital cellulitis with fatal result were observed, the sinusitis in these patients appearing to have been general. In one patient with ethmoiditis and orbital cellulitis the influenza bacillus was found in abundance in the purulent discharge (Base Hospital, Fort Riley).

In one soldier entered in United States General Hospital No. 11, Cape May, a foreign body (fragment of shell) was located in a posterior sphenoidal cell and was the cause of marked contraction of the visual fields while it remained in situ.

Necrosis of the superior orbital ridge as a sequel of orbital cellulitis was observed.

FOCAL INFECTIONS.

A number of ocular disorders directly traceable to focal infections are recorded in several of the camp hospital reports and the following diseases receive mention in this respect: Acute and chronic conjunctivitis, blepharitis, scleritis, keratitis (ulcerative, and parenchymatous—keratitis profunda), iritis, choroiditis, and optic neuritis [1]

Although dental and peridental infections were responsible for the majority of these ocular disorders and the happy results of the removal of the diseased teeth in the treatment of iritis has been referred to (p. 569), their number is not large. Doubtless the care with which the soldiers' teeth and tonsils were inspected and morbid conditions removed accounts for the fact that focal infection in these regions was not more frequently listed as a cause of eye affections, notably those of the uveal tract. The straightening of a deviated nasal septum resulted in the cure of an ulcer in the cornea, and an unusual source of focal infection which had caused iritis was found in adenoid tissue, removal of which effected the cure.

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CHAPTER IV.

ADDITIONAL SPECIAL REPORTS AND CASE HISTORIES.

THE BLIND.

Soldiers who had lost their vision during the war were treated in General Hospital No. 7, Baltimore, Md., which was especially organized for the care of the blind. After the discontinuance of this hospital by the Army they were transferred for training and education to the American Red Cross Institute for the Blind, which functioned in a manner very similar to General Hospital No. 7 and which was managed by a board of directors composed of one educator of the blind, one State commissioner of the blind, two physicians and one representative of the Red Cross. Since December 31, 1921, the Veterans' Bureau has been responsible for the care and instruction of blinded soldiers. The following tabulation includes the history and opthalmologic findings of each blinded or partially blinded man treated in United States General Hospital No. 7:

Prior history and condition on admission of patients, United States General Hospital No. 7, Baltimore, Md.

No.	Patient.	Date of admission.	Prior history.	Condition on admission.
1	M. A., bn. sgt. maj., 147th Inf.	Jan. 19, 1919	Sept. 29, 1918, Argonne Forest, high-explosive shell wound, both eyes. Both eyes enucleated following injury.	Total blindness. Enucleation both eyes.
2	C. E. A., cpl., Co. A, 38th Inf.	Feb. 18, 1919	Oct. 9, 1918, Argonne Forest, high-explosive shell wound, both eyes, face, lower lid. Foreign body right eye, vitreous; also foreign bodies left eye, nonmagnetic.	Vision: 20/40 right eye; light perception left eye. Foreign body both eyes. Traumatic cataract left eye.
3	G. A., pvt., Co. E, 106th Inf.	Jan. 7, 1919	Sept. 25, 1918, St. Quentin sector, shrapnel wound both eyes, chin, and left hand. Optic atrophy right eye due to pressure of foreign body, 9 by 15 mm. in size, pressing against optic nerve. Left eye, opacities vitreous, and retinitis.	Vision: Blind right eye; 7/200 left eye. Optic atrophy right eye. Retinitis left eye. Foreign body right orbit.
4	E. B., pvt., Medical Department.	Jan. 20, 1919	Oct. 2, 1918, Verdun front, high-explosive shell wound head, both eyes, left arm, and hip. Unable to see after injury.	Totally blind. Phthisis bulbi both eyes.
5	J. B., pvt., 1st cl., Hqrs. Co., 23d Inf.	Mar. 2, 1919	Oct. 4, 1918, Champagne front, machine-gun bullet destroying both eyes. Following morning both eyes enucleated.	Totally blind. Enucleation both eyes.
6	L. B., pvt., Co. E, 38th Inf.	Jan. 20, 1919	Oct. 11, 1918, Verdun front, high-explosive shell wound both eyes, head, and face. Following morning remnants both eyes taken out.	Do.
7	H. A. B., cpl., Co. C, 352d Inf.	Jan. 18, 1919	Nov. 16, 1918, injury to both eyes, face, both hands, and both limbs from premature explosion of hand grenade. Caused complete blindness and loss of both hands.	Totally blind. Phthisis bulbi both eyes. Amputation both hands.
8	B. F. B., pvt., Co. F, 305th Eng.	Dec. 7, 1918	July 18, 1918, Chateau Thierry, was gassed (mustard). Developed choroiditis both eyes, as result. Large central patch choroiditis, and floating opacities vitreous right eye. Choroidal changes left eye.	Vision: Light perception right eye; 8/200 left eye. Choroiditis, disseminated bilateral.
9	C. B., pvt., 1st cl., Co. E, 369th Inf.	Nov. 16, 1918	July 15, 1918, Champagne front, high-explosive shell wound both eyes. Also injury to right arm, resulting in paralysis radial side. Both eyes enucleated following injury.	Totally blind. Enucleation both eyes.
10	C. B., civilian, St. Luke's Hospital.	Nov. 23, 1918	Oct. 10, 1917, near Boise, Idaho, was in a dynamite explosion which injured both eyes, head, face, and left forearm. As result, blind both eyes, due to corneal opacities and penetrating wound left eye. Amputation left hand.	Vision: Light perception right eye; blind left eye. Amputation left hand. Corneal opacities, bilateral.

Prior history and condition on admission of patients, United States General Hospital No. 7, Baltimore, Md.—Continued.

No.	Patient.	Date of admission.	Prior history.	Condition on admission.
11	J. B., pvt., Vet. Hospital Corps.	Nov. 2, 1918	Patient claims that he has always had trouble with his eyes. His eye condition was not recognized in service until April, 1918, after arrival in France. Returned to United States May, 1918.	Vision: 10/100 right eye; 4/200 left eye. Optic atrophy, bilateral.
12	J. B., pvt., Co. E, 327th Inf.	Feb. 18, 1919	Oct. 1, 1918, Verdun front, high-explosive shell wound. Injured both eyes and right hip. Both eyes enucleated following day. Ectropion, lower lid, due to scar beneath right eye.	Totally blind. Enucleation both eyes. Ectropion lower lid right eye.
13	C. B., pvt., Co. A, 534th Eng.	.....do........	October, 1918, Bordeaux, had typhoid-pneumonia. While convalescent noticed his eyes being bad. Became totally blind five weeks after sickness began. Probably had meningitis.	Totally blind. Optic atrophy, bilateral.
14	C. H. B., pvt., U. S. M. C.	Feb. 5, 1919	June 15, 1918, was gassed (mustard), Belleau Woods, resulting in dense corneal opacities both eyes.	Dense leucomatous scar, bilateral. Vision: Is able to count fingers at 6 inches. Light perception left eye.
15	W. C. C., cpl., Co. F, 362d Inf.	Jan. 9, 1919	Oct. 31, 1918, Flanders front, bullet wound entering left eye, coming out between right eye and right ear. Three days later left eye enucleated. Right eye shrunken.	Totally blind. Phthisis bulbi right eye. Enucleation left eye.
16	G. M. C., pvt., 1st cl., Co. B, 125th Inf.	Sept. 8, 1918	July 31, 1918, Chateau Thierry, machine-gun bullet entering left eye, coming out right eye. Remains of both eyes enucleated same day. Partial loss of left lower lid. Adhesions of lid to socket left eye.	Totally blind. Enucleation both eyes. Partial loss lower lid and symblepharon left eye.
17	J. C., pvt., Co. C, 23d Inf.	.....do........	April 14, 1918, St. Mihiel sector, high-explosive shell wound both eyes. Left eye enucleated six weeks later. Traumatic catarat right eye. No light perception.	Totally blind. Traumatic cataract right eye. Enucleation left eye.
18	D. C., pvt., Co. M, 9th Inf.	Aug. 8, 1918	April 4, 1918, Verdun front, gassed. While receiving treatment for this, on May 26, 1918, developed spinal meningitis, which affected both eyes.	Vision: 20/70 right eye; 20/50 left eye. Partial optic atrophy, bilateral.
19	J. C., pvt., Bat. C, 120th F. A.	Nov. 16, 1918	Aug. 18, 1918, Chateau Thierry, high-explosive shell wound both eyes, resulting in foreign bodies which are nonmagnetic.	Vision: Light perception right eye; 16/200 left eye. Foreign body with changes in vitreous, both eyes. More marked right eye.
20	J. D. C., cpl., Co. A, 111th M. G	Jan. 9, 1919	Oct. 2, 1918, wounded by high-explosive shell in both eyes, right foot, both thighs, left forearm, and right arm near shoulder. Right eye shrunken about half. Left eye enucleated.	Totally blind. Phthisis bulbi right eye. Enucleation left eye.
21	R. M. C., pvt., 1st cl., Co. E, 314th Eng.	.....do........	Sept. 12, 1918, St. Mihiel sector, high-explosive shell wound both eyes, left ear, and chin. Left eye enucleated same day. Right eye enucleated Sept. 25, 1918.	Totally blind. Enucleation both eyes.
22	E. J. C., pvt., Co. B, 61st Inf.	Mar. 23, 1919	Nov. 6, 1918, Verdun front, shrapnel wounds both eyes. Dec. 2, 1918, left eye enucleated. Right eye, detachment retina lower half.	Vision: Light perception right eye. Enucleation left eye. Detachment retina right eye.
23	B. C., sgt., 1st cl., Medical Dept.	Mar. 25, 1919	Dec. 1, 1918, Fort Riley, Kans., first noticed left eye beginning to fail. Jan. 10, 1919, became totally blind this eye. Right eye began to fail at this time. Has 3/200 vision Apr. 4, 1919, right eye.	Vision: 3/200 right eye; blind left eye. Optic atrophy, bilateral. (Specific.)
24	B. J. C., pvt., Co. F, 165th Inf.	Oct. 24, 1918	July 28, 1918, Chateau Thierry, machine-gun bullet entering right eyebrow, inner side. Two days later right eye enucleated. Seven days later left eye also enucleated.	Totally blind. Enucleation both eyes.
25	R. E. D., 1st lieut., M. G. Co., 146th Inf.	Feb. 21, 1919	Sept. 27, 1918, Verdun front, piece of high-explosive shell penetrated right eye. Following day right eye enucleated. Ten days after injury totally blind. Sight began to return slightly in left eye.	Vision: Blind right eye; 2/200 sight left eye. Enucleation right eye. Optic atrophy, left eye.
26	E. D., U. S. N.	Dec. 3, 1918	About May 15, 1918, Bordeaux, France, sight began to blur, gradually got worse, and became totally blind on Aug. 9, 1918. Eye condition supposedly due to glare from furnace fire of ship.	Totally blind. Optic atrophy, bilateral.
27	J. E., pvt., Co. L, 315th Inf.	Mar. 23, 1919	Sept. 28, 1918, Verdun front, as result of high-explosive shell bursting within 6 feet of him, particles of dirt were thrown into both eyes.	Vision: 10/200 right eye; 3/200 left eye. Corneal opacity, bilateral. Traumatic cataract left eye.
28	C. R. F., sgt., 15th Bn., Medical Dept.	Oct. 11, 1918	Sept., 1918, states that his vision began to get bad and gradually worse until Oct. 1, 1918. February, 1916, gives a history of primary lesion.	Vision: 4/200 right eye; blind left eye. Chororetinitis, bilateral.
29	S. F., pvt., Co. M, 110th Inf.	Jan. 9, 1919	Sept. 5, 1918, Verdun front, machine-gun bullet entering left side of face, coming out right side of face just below outer canthus. Complete detachment of retina right eye. Choroidal rupture left.	Vision: Light perception left eye; blind right eye. Retinal detachment right eye. Choroidal rupture left eye.

Prior history and condition on admission of patients, United States General Hospital No. 7, Baltimore, Md.—Continued.

No.	Patient.	Date of admission.	Prior history.	Condition on admission.
30	E. W. F., pvt., Medical Dept.	Sept. 24, 1918	Nov. 19, 1917, admitted to Base Hospital, Camp Bowie, Tex.; diagnosis measles. Dec. 23, 1917, developed suppurative otitis media, also mastoiditis, for which he was operated upon. Apr. 6, 1918, developed optic neuritis. Examination at the present time shows central scotoma. Field of vision contracted.	Vision: 5/200 right eye; 8/200 left eye. Retrobular neuritis, bilateral, with atrophy of optic nerve.
31	F. W., pvt., 1st cl., Co. A, 359th Inf.	Jan. 9, 1919	Sept. 23, 1918, Toul front, rifle bullet injuring right side of face and eye, with considerable loss of bone and tissue below right eye. Left eye reveals choroidal rupture extending from disc to macula.	Vision: Blind right eye; 20/200 left eye. Enucleation right eye. Choroidal rupture left eye.
32	W. E. F., pvt., Co. I, 352d Inf.	.....do........	Sept. 15, 1918, St. Mihiel, several wounds of face, both eyes, and left shoulder, resulting from hand-grenade explosion. Both eyes enucleated General Hospital No. 7.	Totally blind. Enucleation both eyes.
33	R. F., sgt., Co. D, 60th Inf.	Mar. 23, 1919	Nov. 10, 1918, Argonne front, high-explosive shell wound both eyes, right wrist, right and left thigh. Right eye enucleated Nov. 11, 1918. Right upper lid drawn into scar located outside of outer canthus.	Totally blind. Enucleation right eye. Phthisis bulbi left eye.
34	J. P. F., pvt., Hdqrs. Co., 160th Brig.	Mar. 18, 1919	Oct. 4, 1918, Argonne front, injury of both eyes as result of concussion of high-explosive shell. Intraocular hemorrhage right eye. Choroidal rupture left eye on nasal side of disc.	Vision: Light perception right eye; left eye, 2/200 vision. Intraocular hemorrhage right eye. Choroidal rupture left eye.
35	D. G., pvt., Co. C, 144th Inf.	June 9, 1918	Mar. 21, 1918, Camp Bowie, Tex., developing gonorrheal ophthalmia and keratitis, resulting in dense leucomatous scars both eyes with complete loss of vision.	Totally blind. Dense leucomatous scars, bilateral.
36	L. G., pvt., Co. F, 325th Inf.	Feb. 18, 1919	Aug. 3, 1918, Toul sector, as result of hand-grenade explosion, both eyes, left hand, and left leg injured. Numerous opacities vitreous right eye. Foreign body left eye. Traumatic cataract.	Vision: 10/200 right eye; light perception left eye. Shell wound right eye. Traumatic cataract left eye.
37	H. E. G., cpl., Co. G, 18th Inf.	Sept. 26, 1918	July 21, 1918, Chateau Thierry, high-explosive shell wound both eyes. As result, developed phthisis bulbi both eyes with no light perception. Both eyes enucleated General Hospital No. 7.	Totally blind. Enucleation both eyes.
38	G. G., pvt., Co. K, 371st Inf.	Jan. 13, 1919	Nov. 1, 1918, Champagne front, shrapnel wound of right eye and left arm. Left eye injury probably from concussion. Enucleation right eye. Choroidal rupture lower right quadrant fundus left eye.	Vision: Blind right eye; 4/200 vision left eye. Enucleation right eye. Choroidal rupture left eye.
39	G. J. G., pvt., 1st cl., Co. A, 18th Inf.	Nov. 16, 1918	July 18, 1918, near Soissons, France, high-explosive shell wound both eyes, face, and body. Left eye enucleated following day. Detachment of retina and dislocated lens right eye.	Vision: Totally blind. Detached retina and dislocated lens, right eye. Enucleation left eye.
40	F. H., musician, Hqrs. Co., 58th Inf.	Jan. 9, 1919	Aug. 10, 1918, Chateau Thierry sector, gassed. Aug. 13, 1918, noticed sight beginning to fail. No history of previous poor vision.	Vision: 4/200 right eye and left eye. Optic atrophy, bilateral.
41	J. H. H., pvt., unassigned.	Mar. 6, 1919	Nov. 12, 1918, patient injured both eyes by accidental discharge of gun near Louisville, Ky. Unable to see out of either eye since. Organized blood clot in vitreous both eyes.	Totally blind. Gunshot wound bilateral.
42	A. H., pvt., Co. C, 117th F. S. C.	Dec. 12, 1918	July 30, 1918, Chateau Thierry sector, gassed. Eyes became inflamed and swollen. Aug. 24, 1918, developed ulcers cornea both eyes.	Vision: 5/200 right eye; 20/200 left eye. Corneal opacities, bilateral.
43	E. A. H., bugler, Co. F, 103d Eng.	Jan. 9, 1919	Oct. 2, 1918, Verdun front, high-explosive shell wound of face and both eyes. Has been unable to see since. Both eyes shrunken about one-third normal size.	Totally blind. Phthisis bulbi, bilateral.
44	N. H., pvt., 1st cl., Co. I, 370th Inf.	Feb. 18, 1919	Sept. 18, 1918, Soissons front, high-explosive shell wound both eyes. Right eye enucleated three weeks later. Left eye reveals choroidal rupture surrounding disc, extending downward and outward.	Totally blind. Enucleation right eye. Choroidal rupture left eye.
45	R. E. H., pvt., Medical Dept.	Mar. 27, 1919	When 14 years of age, first noticed being troubled with night blindness. His eyes have been gradually getting worse ever since. No worse as result of service. Deposit of retinal pigment terminal branches of retinal arteries.	Vision: 20/30 both eyes. Retinitis pigmentosa, bilateral.
46	P. L. H., sgt., Co. 12, M. T. C.	Jan. 20, 1919	Troubled with night blindness when 9 years of age. States that as a result of service, his eyes are somewhat weaker. Disc, both eyes, grayish white in appearance. Clumping of retinal pigment noted about terminal branches of retinal arteries.	Vision: 20/50 both eyes. Retinitis pigmentosa, beginning secondary optic atrophy.
47	L. H. H., cpl., Co. L, 128th Inf.	Jan. 9, 1919	Sept. 10. 1918, Soissons, shrapnel wound left side of face, right eye, and right arm. Right eye enucleated. Optic atrophy left eye. Considerable loss of tissue and bony structures beneath right eye requiring plastic operation.	Totally blind. Enucleation right eye. Optic atrophy left eye.

Prior history and condition on admission of patients, United States General Hospital No. 7, Baltimore, Md.—Continued.

No.	Patient.	Date of admission.	Prior history.	Condition on admission.
48	J. E. H., sgt., Co. K, 39th Inf.	Jan. 9, 1919	Sept. 29, 1918, Verdun front, bullet wound which entered right side of face, coming out left eyebrow. As a result, developed phthisis bulbi both eyes.	Totally blind. Phthisis bulbi, bilateral.
49	J. J., pvt., Co. G, 16th Inf.	Nov. 16, 1918	June 6, 1918, Cantigny, shrapnel wound both eyes. Right eye enucleated following injury. Penetrating wound left eye with resulting traumatic cataract. Totally blind until Feb. 4, 1919, when a discission was done which gave him 20/100 vision corrected to 20/30.	Vision: Blind right eye. Penetrating wound left eye, resulting in traumatic cataract. After operation, vision corrected to 20/30.
50	M. J., pvt., Co. C, 112th Inf.	Jan. 9, 1919	June 9, 1918, Viele sector, injury to both eyes, head, face, and left arm from hand-grenade explosion. Aug. 18, 1918, left eye enucleated. Piece of steel removed right eye Sept. 9, 1918.	Vision: Totally blind left eye; 10/200 right eye. Traumatic keratitis, with resulting numerous opacities cornea. Enucleation left eye.
51	N. E. J., pvt. Co. C, 308th Inf.	.....do........	Sept. 27, 1918, Argonne front, as result of hand-grenade explosion, both eyes were injured. Right eye shrunken about one-third. Traumatic cataract left eye, with no light perception.	Totally blind. Phthisis bulbi right eye. Traumatic cataract left eye.
52	H. E. K., cpl., Co. F, 315th Inf.	Feb. 18, 1919	Sept. 28, 1918, Verdun sector, high-explosive shell wound both eyes and left arm. Right eye shrunken about one-fourth of its normal size. Lower lid drawn into scar beneath this lid. Left eye shrunken half its normal size.	Totally blind. Phthisis bulbi, bilateral.
53	M. J. K., pvt., Co. G, 127th Inf.	Jan. 20, 1919	Oct. 14, 1918, Verdun sector, high-explosive shell wound both eyes and head. Right eye enucleated at this time. Left eye markedly shrunken. Upper lid left eye drawn into scar above.	Totally blind. Enucleation right eye. Phthisis bulbi left eye.
54	H. C. K., pvt., Co. C, 41st Eng.	Dec. 5, 1918	Aug. 8, 1918, Allichamp, high-explosive shell wound both eyes. Right eye enucleated following injury. Left eye reveals large, proliferating mass in vitreous. Only light perception in this eye.	Blind right eye. Light perception left eye. Enucleation right eye. Retinitis proliferans left eye.
55	L. K., pvt., Co. L, 137th Inf.	Jan. 9, 1919	Sept. 28, 1918, Verdun sector, shrapnel wound both eyes. Right eye enucleated. Left eye shrunken. Has no light perception.	Totally blind. Enucleation right eye. Phthisis bulbi left eye.
56	A. K., pvt., 1st cl., U. S. M. C.	Feb. 5, 1919	Oct. 4, 1918, Champagne front, sniper's bullet entering beneath left eye, coming out just beneath right eye. Right eye enucleated same night. Left eye enucleated Apr. 15, 1919.	Totally blind. Enucleation both eyes.
57	R. K., pvt., Co. L, 361st Inf.	Jan. 9, 1919	Sept. 27, 1918, Verdun sector, high-explosive shell wound of both eyes, with complete destruction of both eyes and lower lid left eye. Remnants of eye removed following injury.	Do.
58	C. V. K., pvt., Co. E, 315th Inf.	Mar. 23, 1919	Nov. 7, 1918, Argonne Forest, high-explosive shell wound both eyes. Following day left eye enucleated. Right eye reveals choroidal rupture completely destroying nerve head and extending downward and outward.	Totally blind. Choroidal rupture right eye. Enucleation left eye.
59	S. F. K., pvt., Co. C, 142d Inf.	Jan. 20, 1919	Oct. 8, 1918, Champagne front, shrapnel wound entering right side of face below malar bone, coming out lower left eye. Right eye shrunken. Left choroidal rupture extending downward and outward from disc.	Vision: Blind right eye; 2/200 left eye. Phthisis bulbi right eye. Choroidal rupture left eye.
60	W. H. K., pvt., Co. E, 311th Inf.	Feb. 19, 1919	Oct. 27, 1918, Argonne front, high-explosive shell wound, resulting in total blindness. Right eye, detached retina, intraocular hemorrhage. Left eye enucleated. Lower lid left eye drawn into scar, beneath.	Totally blind. Detached retina, intraocular hemorrhage, right eye. Enucleation left eye.
61	R. K., pvt., Co. C, 130th Inf.	Sept. 12, 1918	June 12, 1918, eyes first gave him trouble. Examination revealed opacities vitreous. Choroidal and retinal changes both eyes. Highly myopic.	Vision: 7/200 right eye; 20/200 left eye. Chorioretinitis, bilateral, and myopia.
62	G. L., pvt., Co. G, 10th Am. Trn.	Oct. 8, 1918	Aug. 16, 1918, first noticed his eyes giving him trouble. Developed at this time superficial keratitis, both eyes, supposed to have been due to recurrent nasal sinus disease, with infection of ear.	Vision: 20/70 both eyes. Corneal opacities bilateral.
63	H. I. L., pvt., Co. E, 306th Inf.	Feb. 18, 1919	Oct. 14, 1918, Verdun front, as result of high-explosive shell wound, both eyes severely injured. Both eyes enucleated shortly after injury. Large granulomatous mass lower lid right eye.	Totally blind. Enucleation both eyes.
64	P. L., pvt., Co. D, 115th Eng.	Dec. 14, 1918	1911, first noticed eyes were weak, but did not give him much trouble till Oct. 26, 1918. Examination revealed central choroiditis, bilateral, with marked nystagmus. Cause undertermined.	Vision: 1/200 right eye; 15/200 left eye. Atrophic choroiditis, bilateral.

Prior history and condition on admission of patients, United States General Hospital No. 7, Baltimore, Md.—Continued.

No.	Patient.	Date of admission.	Prior history.	Condition on admission.
65	E. L., pvt., Co. G, 354th Inf.	Jan. 9, 1919	Sept. 13, 1918, Toul sector, as result of hand-grenade explosion both eyes were injured. Left eye reveals detachment of retina and traumatic cataract. Right eye, traumatic cataract which was needled, giving him 20/30 vision with correcting lens.	Vision: Blind right eye; 20/30 left eye. Detachment of retina, and traumatic cataract right eye. Penetrating wound left eye.
66	R. L., cpl., Co. B, 102d Inf.	Dec. 7, 1918	July 14, 1918, near Chateau Thierry, was gassed. As result developed conjunctivitis and superficial keratitis, bilateral.	Vision: 15/200 right eye; 20/70 left eye. Corneal opacities, bilateral.
67	M. G. M., pvt., Co. F, 167th Inf.	Jan. 9, 1919	Oct. 7, 1918, Verdun front, high-explosive shell wound both eyes. X ray revealed foreign body 1 by ¼ inch inside skull, temporal region, on line with top of orbit.	Totally blind. Optic atrophy right eye. Phthisis bulbi left eye.
68	T. M., seaman, 2d cl., U. S. N.	May 29, 1918	Jan. 10, 1918, admitted to Brooklyn Naval Hospital with meningitis. Unconscious for about two weeks. Not able to see since. Both eyes shrunken about half.	Totally blind. Phthisis bulbi, bilateral, following meningitis.
69	W. A. M., pvt., Co. G, 112th Inf.	June 14, 1918	Jan. 6, 1918, Camp Hancock, Ga., developed cerebrospinal meningitis. Four days later became totally blind. Examination revealed traumatic cataract both eyes and beginning shrinking of eyeball.	Totally blind. Cataracts and phthisis bulbi, bilateral, due to meningitis.
70	J. M., civilian.....	Sept. 12, 1918	Oct. 15, 1917, while blasting rock at Flat Head Reservation, Mont., as result of premature explosion, both eyes were injured, resulting incomplete blindness. Feb. 17, 1919, left eye enucleated. Right eye pupil completely occluded. Partial iridectomy performed.	Vision: Can count fingers at 6 inches with right eye. Left eye enucleated. Penetrating wound right eye.
71	J. J. M., pvt., Co. E, 165th Inf.	Feb. 23, 1919	Oct. 29, 1918, Argonne front, result of hand-grenade explosion, right eye, left hip, and inner part of right thigh injured. Right eye: Lens cloudy. Left eye: Highly hyperopic. Vision, 5/200 corrected to 20/100.	Vision: Can count fingers at 8 inches with right eye; left eye 20/100. Traumatic cataract right eye. Amblyopia and hyperopia left eye.
72	E. M., cpl., Co. A, 327th Inf.	Jan. 9, 1919	Sept. 28, 1918, Argonne front, high-explosive shell wound both eyes. Examination revealed both eyes shrunken about one-third normal size. Also adhesion between upper lid and left eyeball.	Totally blind. Phthisis bulbi, bilateral.
73	H. C. M., pvt., Co. A, 18th Inf.	.....do.......	Oct. 9, 1918, Verdun front, machine-gun bullet entered brow right eye, coming out just outside of outer canthus left eye. Examination right eye revealed intraocular hemorrhage, choroidal rupture, and retinal detachment. Left eye shrunken about half.	Vision: 6/200 right eye; blind left eye. Intraocular hemorrhage, choroidal rupture, and retinal detachment right eye. Enucleation left eye.
74	J. M., pvt., Co. F, 368th Inf.	.....do.......	Sept. 27, 1918, Argonne front, high-explosive shell wound both eyes. Two days after injury both eyes enucleated.	Totally blind. Enucleation both eyes.
75	S. M., pvt., Co. M, 64th Inf.	Mar. 23, 1919	Oct. 12, 1918, Verdun sector, severely gassed, burning eyes, face, hands, and other parts of the body. On Nov. 10, 1918, right eye enucleated because of slough cornea and panophthalmitis. Left eye reveals dense opacity of cornea.	Totally blind. Enucleation right eye. Dense corneal scar left eye.
76	G. A. M., cpl., Co. F, 109th Inf.	Dec. 1, 1918	July 17, 1918, Chateau Thierry, shrapnel wound left side of head, injuring both eyes. Examination, right eye shrunken about one-third. Left eye revealed choroidal rupture extending from nasal side of disc around disc to macula.	Totally blind. Phthisis bulbi right eye. Choroidal rupture left eye.
77	S. N., sgt., Co. C, 11th Inf.	Feb. 18, 1919	Sept. 14, 1918, St. Mihiel sector, machine-gun bullet which entered left eyebrow causing complete destruction of both eyes, upper part of face, base of nose opening up nasal fossæ.	Totally blind. Loss of both eyes. Open shell wound upper part of face, requiring plastic operation.
78	F. N., pvt., Co. L, 9th Inf.	.....do.......	Oct. 1, 1918, Argonne front, high-explosive shell wound both eyes, both hands. Following this injury he was never able to see. Perforation of ear drum.	Totally blind. Enucleation both eyes.
79	E. J. P., pvt., 1st. cl., Hqrs. Co., 107th Inf.	Dec. 27, 1918	May 21, 1918, Pas, France, as result of high-explosive shell, was blown about 10 feet, which produced double inguinal and umbilical hernia. One week later vision right eye affected. Examination revealed traumatic cataract.	Vision: Right eye blind; left eye, 20/70. Traumatic cataract right eye. Amblyopia left eye, due to divergent strabismus.
80	J. P., pvt., Co. D, 57th Inf.	Jan. 9, 1919	Troubled with night blindness since he was 10 years of age. States that his vision is worse since being in the service. Examination reveals slumping of retinal pigment terminal branches of retinal arteries both eyes.	Vision: 20/200 both eyes. Retinitis pigmentosa, beginning secondary optic atrophy.
81	C. P., cpl., U. S. M. C.	Apr. 8, 1919	June 9, 1918, Chateau Thierry, high-explosive shell wound both eyes, right hand, face, and body. June 14, left eye enucleated. Right eye shrunken about one-third.	Totally blind. Phthisis bulbi right eye. Enucleation left eye.
82	F. E. P., pvt., Co. D, 57th Eng.	Dec. 31, 1918	Sept. 12, 1918, Brest, France, developed cerebrospinal meningitis. Two days was unable to see. Both eyes shrunken about one-fourth of their normal size. Cornea both eyes cloudy.	Totally blind. Phthisis bulbi, bilateral, due to meningitis.

Prior history and condition on admission of patients, United States General Hospital No. 7, Baltimore, Md.—Continued.

No.	Patient.	Date of admission.	Prior history.	Condition on admission.
83	E. R., pvt., Co. E, 144th Inf.	Jan. 9, 1919	Oct. 11, 1918, Champagne front, shrapnel wound both eyes, face, and hand. Unable to see since injury. Both eyeballs shrunken and irregular in shape.	Totally blind. Phthisis bulbi, bilateral.
84	H. M. R., pvt., Co. M, 60th Inf.	Mar. 6, 1919	Oct. 11, 1918, Argonne front, shrapnel wound which entered right side of face coming out left side. Completely blinded following injury. Sight gradually returned left eye. Right eye shrunken. Choroidal rupture from disc to macula, left eye.	Vision: Blind right eye; 3/200 left eye. Phthisis bulbi right eye. Choroidal rupture left eye.
85	B. R., pvt., Co. G, 16th Inf.	Sept. 8, 1918	June 5, 1918, Cantigny, France, shrapnel wound both eyes, right ankle, right knee, and right hand. Right eye: Traumatic cataract. Discission was done on this eye Feb. 27, 1919. Because of vitreous changes, practically no vision was obtained.	Vision: Can count fingers with right eye at 1 inch; blind left eye. Penetrating wound right eye. Enucleation left eye.
86	J. J. R., pvt., Co. M, 316th Inf.	Jan. 9, 1919	Aug. 1, 1918, Cantigny, France, first noticed his eyes giving him trouble. At this time developed keratitis (interstial) and conjunctivitis. Cause undetermined.	Vision: 1/200 both eyes. Corneal opacities, bilateral.
87	E. M. R., cpl., Co. A, 16th Inf.	Jan. 20, 1919	Feb. 8, 1918, Lorraine sector, was knocked unconscious by hand-grenade explosion and captured. Unable to see since. Right eye enucleated. Penetrating wound left eye. Totally blind.	Totally blind. Enucleation right eye. Penetrating wound left eye.
88	M. R., pvt., Co. D, 316th Inf.	.....do........	Oct. 14, 1918, Verdun front, shrapnel wound both eyes. Examination right eye revealed intraocular hemorrhage and detachment of retina. Left eye, phthisis bulbi, resulting from penetrating wound.	Totally blind. Detachment of retina and intraocular hemorrhage right eye. Phthisis bulbi, left eye.
89	F. S., 2d lieut., Co. K, 318th Inf.	Dec. 16, 1918	Oct. 5, 1918, Argonne sector, high-explosive shell wound entering left eye, coming out right side of face. Left eye enucleated shortly after. Examination right eye revealed choroidal rupture, nasal side of fundus, and detachment of retina.	Totally blind. Choroidal rupture and detachment of retina right eye. Also optic atrophy right eye. Enucleation left eye.
90	W. S., pvt., Co. I, 33d Inf.	Mar. 24, 1919	Dec. 19, 1918, Camp Lee, Va., developed cerebrospinal meningitis. Examination revealed cataracts and iridocyclitis, bilateral.	Vision: 1/200 both eyes. Cataracts and iridocyclitis, bilateral.
91	T. M. S., pvt., Co. A, 26th Inf.	Aug. 2, 1918	August, 1917, first noticed his eyes giving him trouble. Entered Base Hospital No. 18 on Nov. 25, 1917. Diagnosis of glaucoma, noninflammatory. Vision has gradually failed. Feb. 17, 1919, trephine operation done on right eye. Mar. 26, 1919, same operation on left eye.	Vision: Light perception right eye; 20/200 left eye. Glaucoma, bilateral, noninflammatory.
92	F. S., pvt., 1st cl., Co. B, 30th Inf.	Nov. 1, 1918	Sept. 15, 1918, Somme sector, high-explosive shell wound both eyes, right shoulder, and right knee. Both eyes enucleated two days later.	Totally blind. Enucleation both eyes.
93	H. S., pvt., Co. G, 9th Inf.	Sept. 8, 1918	July 18, 1918, machine-gun bullet entered right temple coming out left eye. Following day both eyes enucleated at American Red Cross No. 2. Upper lid right eye adherent to wound on nasal side. Also lower lid.	Do.
94	A. S., pvt., Co. H, 107th Inf.	Jan. 16, 1919	Sept. 29, 1918, St. Quentin front, high-explosive shell wound right hand, right leg above knee, and both eyes. Examination right eye, disc atrophic. Left eye shrunken about one-half.	Totally blind. Optic atrophy right eye; phthisis bulbi left eye.
95	L. S., pvt., Co. H, 120th Inf.	Jan. 9, 1919	Oct. 11, 1918, Flanders front, received high-explosive shell wound both eyes. Result complete blindness. Right eye enucleated five days after. Left eye shrunken about one-third.	Totally blind. Enucleation right eye. Phthisis bulbi left eye.
96	B. S., pvt., Co. M, 369th Inf.	Mar. 23, 1919	September, 1918, Argonne sector, left eye began to pain and vision became blurred. This eye rapidly grew worse until Nov. 20, 1918, when it was enucleated, because of acute glaucoma. Right eye tension high; retinal detachment; fundus reflex present upper part only.	Vision: 20/100 right eye; blind left eye. Glaucoma noninflammatory, right eye. Enucleation left eye.
97	E. S., pvt., Co. H, 28th Inf.	Jan. 9, 1919	Oct. 5, 1918, Verdun front, shrapnel wound both eyes and upper part of face, with considerable loss of tissue in bony structures. Following day remnants of both eyes removed.	Totally blind. Enucleation both eyes.
98	E. C. S., pvt., Co. I, 11th Inf.	Feb. 21, 1919	Sept. 5, 1918, Chateau Thierry, shrapnel wound both eyes. Examination right eye revealed choroidal rupture extending outward and upward from macula. Left eye, optic atrophy and disseminated choroiditis.	Vision: 10/200 right eye; able to count figures at 6 inches with left eye. Choroidal rupture right eye. Optic atrophy and disseminated choroiditis left eye.
99	L. S., pvt., Co. D, 115th Inf.	Nov. 12, 1918	July, 1918, in France, got some dirt into his eye which caused him to go blind in his left eye. Examination revealed cataract and chronic iridocyclitis. Right eye, myopic astigmatism, with 10/200 vision corrected to 20/70.	Vision: Right eye 20/70; left eye blind. Myopic astigmatism and amblyopia right eye. Traumatic cataract and iridocyclitis left eye.

Prior history and condition on admission of patients, United States General Hospital No. 7, Baltimore, Md.—Continued.

No.	Patient.	Date of admission.	Prior history.	Condition on admission.
100	G. T., pvt., 1st cl., Co. B, 28th Inf.	Apr. 4, 1919	September, 1918, Mangiere, France, developed influenza. At this time vision became blurred. Sight gradually became worse, until March, when he became practically blind. Examination reveals neuroretinitis both eyes.	Totally blind. Neuroretinitis, bilateral.
101	F. V., civilian....	July 25, 1918	Jan. 26, 1918, naval torpedo station, Newport, R. I., as a result of torpedo explosion both eyes, face, and right arm were injured. Examination reveals traumatic cataract right eye. Has no light perception right eye. Exclusion of pupil with iris bombi left eye. Ankylosis of right elbow joint.	Totally blind. Traumatic cataract right eye. Exclusion of pupil with iris bombi left eye. Ankylosis right elbow joint.
102	B. J. W., pvt., Co. D, 501st Eng.	Apr. 14, 1918	Jan. 19, 1918, patient was ordered to hospital on account of night blindness. As long as he can remember says he has been troubled with night blindness. Examination reveals clumping of retinal pigment terminal branches of retinal arteries, and optic atrophy; more marked in right eye.	Vision: Blind right eye; 20/100 vision left eye. Retinitis pigmentosa and optic atrophy bilateral.
103	E. W., pvt., M. G. Co., 128th Inf.	Feb. 18, 1919	Oct. 7, 1918, Argonne front, injured by high-explosive shell both eyes, right hand, and left knee. Right eye enucleated four days after injury. Left eye shrunken.	Totally blind. Enucleation right eye. Phthisis bulbi left eye.
104	P. A. W., pvt., 1st cl., Co. F, 56th Inf.	Jan. 20, 1919	Nov. 1, 1918, Toul sector, high-explosive shell wound both eyes and left arm. Dec. 11, right eye enucleated. Left eye reveals traumatic cataract, which is undergoing absorption.	Vision: Blind right eye. Good light perception left eye. Enucleation right eye. Traumatic cataract left eye.
105	W. W., pvt., Co. D, 305th Inf.	Feb. 18, 1919	Sept. 29, 1918, Argonne front, as result of hand-grenade explosion, both eyes and left hand injured. Right eye enucleated and left hand amputated following injury. Left eye shrunken about one-third.	Totally blind. Enucleation right eye. Phthisis bulbi left eye. Amputation left hand.
106	J. A. W., pvt., Co. K, 310th Inf.	Jan. 9, 1919	Sept. 22, 1918, Argonne sector, as a result of hand-grenade explosion, both eyes were injured. Right eye enucleated same day. Left eye reveals traumatic cataract. Deep depression back of ciliary region. Has no light perception.	Totally blind. Enucleation right eye. Traumatic cataract left eye.
107	H. C. W., pvt., Co. 50, 159th D. B.	May 29, 1918	Feb. 10, 1918, first noticed his eyes giving him trouble. Apr. 5, 1918, following spinal puncture for intravenous injection of medicine, his eyes rapidly grew worse. Has only slight light perception, both eyes. Specific infection February, 1908.	Vision: Light perception only, both eyes. Optic atrophy, bilateral.
108	W. H. S., sgt., Ordnance Dept.	Apr. 20, 1918	Nov. 3, 1917, while in France, truck skidded and turned over. Patient was pinned beneath. Chest, abdomen, and left side of pelvis injured. At this time had numerous hemorrhages retina of both eyes. Examination revealed optic atrophy, both eyes.	Totally blind. Optic atrophy, bilateral.
109	P. C., pvt., P. S. C., 83d Div.	Apr. 10, 1919	About Dec. 20, 1918, LaMange, France, first noticed his eyes becoming weak. Eyes gradually failed. Toward the latter part of February, 1919, he became totally blind in right eye. Examination reveals optic atrophy, bilateral.	Vision: Blind right eye; 20/100 vision left eye. Optic atrophy bilateral.
110	J. E. C., pvt., Co. F, 349th Inf.	.....do.......	Nov. 2, 1918, while in France, as a result of of hand-grenade explosion, he was struck in left eye. Gives a history of poor vision in right eye before entering the service. Examination reveals choroiditis and optic atrophy, right eye. Left eye traumatic cataract.	Vision: 10/200 right eye; totally blind left eye. Atrophic choroiditis and optic atrophy right eye. Traumatic cataract left eye.
111	F. C., pvt., Co. H, 308th Inf.	Apr. 9, 1919	Sept. 27, 1918, Argonne front, as result of hand-grenade explosion, both eyes, face, and arm injured. Extensive choroidal rupture lower right-hand quadrant, right eye. Left eye revealed detachment of retina nearly complete.	Vision: Can count fingers at 6 inches with right eye. Blind left eye. Choroidal rupture right eye. Retinal detachment left eye.
112	L. C. D., pvt., 43d Co., 5th U. S. M. C.	Apr. 1, 1919	Nov. 11, 1918, Argonne front, high-explosive shell wound in region of left occipital lobe. Sight was affected immediately. Perimeter shows sharp line cutting off left half of each retina. Wernicke test shows lesion to be posterior to the primary optic nucleus.	Vision: 1/200 both eyes; left homonymous hemianopsia.
113	H. J., pvt., Co. B, 4th Inf.	Apr. 14, 1919	Oct. 16, 1918, Verdun front, shrapnel wound entered between outer canthus left eye and ear, coming out right eye. Right eye enucleated shortly after injury. Left eye, choroidal rupture, detachment of retina, and phthisis bulbi.	Totally blind. Enucleation right eye. Choroidal rupture, retinal detachment, and phthisis bulbi left eye.

Prior history and condition on admission of patients, United States General Hospital No. 7, Baltimore, Md.—Continued.

No.	Patient.	Date of admission.	Prior history.	Condition on admission.
114	H. J. W., bugler, Co. B, 318th Inf.	Apr. 15, 1919	Aug. 9, 1918, Flanders sector, high-explosive shell wound of both eyes and head. Left eye enucleated shortly after. Right eyeball shrunken about three-fourths. Feb. 1, 1919, had plastic operation, when base of nose was restored.	Totally blind. Phthisis bulbi right eye. Enucleation left eye.
115	I. S. C., sgt., Co. A, 109th Inf.	Sept. 18, 1918	July 15, 1918, Marne, high-explosive shell wound of both eyes and upper part of face. Examination reveals both eyes shrunken about one-third and irregular in shape. Died Feb. 5, 1918, at General Hospital No. 2, Fort McHenry, Md., from cerebrospinal meningitis.	Totally blind. Phthisis bulbi, bilateral.
116	C. P. A., pvt., 1st cl., Co. H, 353d Inf.	Apr. 17, 1919	Oct. 1, 1918, St. Mihiel front, both eyes and face badly burned by mustard gas. Examination, both eyes, reveals evidence of chronic inflammation of the lids and bulbar conjunctiva. Dense leucomatous scars covering entire cornea, both eyes.	Light perception only, both eyes. Dense leucomatous scars, bilateral.
117	J. C. R., sgt., Co. F, 324th Inf.	.....do.......	Nov. 9, 1918, Verdun front, machine-gun bullet, which entered right side of face beneath right eyebrow, coming out beneath left eyebrow, left side of face. Right eye shrunken about one-fifth. Complete detachment of retina this eye. Left eye enucleated Nov. 11, 1918.	Totally blind. Retinal detachment and phthisis bulbi right eye. Enucleation left eye.

SUMMARY.

	Cases.
1. Total blindness	65
2. One eye totally blind, or with only light perception; the other eye with vision less than 1/20.	27
3. Only light perception, or with vision less than 1/20, both eyes	11
4. Light perception, or with vision less than 1/20, one eye; better than 1/20, other eye	8
5. Vision better than 1/20, both eyes	6
Total	117

The chief causes of blindness, one or both eyes, are enumerated as follows:

Choroiditis	6	Optic neuritis	1
Choroidal rupture	6	Optic nerve atrophy	19
Corneal leucoma	12	Phthisis bulbi	29
Detachment of retina	9	Retinitis pigmentosa	1
Double enucleations	18	Traumatic cataract	9
Glaucoma	2	Total	117
Iridocyclitis	3		
Intraocular foreign bodies	2		

OPHTHALMIC SYMPTOMS IN INJURY OF THE CERVICAL SYMPATHETIC NERVE.

Enophthalmos was noted in several of the hospitals listed; in the majority of instances it was due to injury of the cervical sympathetic nerve. A complete study from all standpoints of every case of the Claude Bernard-Honer syndrome resulting from such injury was made in United States General Hospital No. 11, Cape May.[1] Only a summary of the diagnosis and ocular symptoms are here reproduced.

CASE 1.—Pvt., Co. K, 30th Inf. Aged 23 years. Diagnosis: (1) Injury to left brachial plexus, at first involving the whole structure, but improving, and in six months leaving a paraylsis only of the seventh and eighth cervical segments. (2) Injury to the sympathetic fibers lying in the seventh and eighth cervical roots, left. Ophthalmological examination: Enophthalmos, ptosis, and myosis left side marked. Left palpebral fissure 10 mm., right 13 mm. Both pupils reacted to L. A. and C., but left slower than right. Diameter left pupil $2\frac{1}{2}$ mm., right $3\frac{1}{2}$ mm. Under cocaine, left $2\frac{1}{2}$ mm., right 5 mm. Tension left eye 13 mm. Hg., right 17 mm. Hg. No heterochromia iridis.

Vision 20/20 in both eyes. Near point, left 11 cm., right 12 cm. Ocular movements normal. Left globe slightly elevated and left nictitating membrane slightly more prominent than right. Left cornea appeared a little flatter than right. On excursion of the eye to the right, the difference in the size of the pupils increased slightly, while on turning to the left the difference diminishes slightly. Fundi and fields normal. No flushing of face nor hemiatrophy noted. Lacrymation normal.

Case 2.—Pvt., Co. L, 18th Inf. Aged 24 years. Diagnosis: (1) Evulsions of the sixth, seventh, and eighth cervical roots and of the first thoracic root on the right brachial plexus, with contusion and fibrosis, resulting in complete sensory and motor paralysis of the right arm. (2) Interruption of the cervical-sympathetic fibers, by the evulsion of the sixth, seventh, and eighth cervical and first thoracic spinal roots, right.[a] Ophthalmological examination: Enophthalmos, ptosis, myosis of right side marked. Right palpebral aperture 9 mm., left 12 mm. Pupillary reactions normal, but right slightly retarded. Diameter right pupil 2½ mm., left 6 mm. Width under cocaine, right 2½ mm., left 9 mm. Ocular tension, right 12 mm. Hg., left 16 mm. Hg. Vision, 20/15 both eyes. Near-point, right 9 cm., left 10½ cm. Right eye slightly elevated. Ocular movements normal. On excursion of the eyes to the right difference in the size of pupils diminished; on excursion to the left the difference in size increased slightly. Fundi and fields normal. This patient showed a slight hemiatrophy of the right side of the face.

Case 3.—Pvt., Co. C, 58th Inf. Aged 27 years. Diagnosis: (1) Contusion of left brachial plexus, with a severe lesion of the fifth cervical root, causing a more permanent scapulohumeral type of paralysis. (2) Partial paralysis of the left recurrent laryngeal nerve. (3) Lesion of left cervical sympathetic nerve. Ophthalmological examination: Enophthalmos, ptosis, and myosis of left eye marked. Left palpebral aperture 7 mm., right 10 mm. Pupils reacted normally, left being slightly slower than right; width of left pupil 2½ mm., right 3½ mm. Under cocaine, left 2½ mm., right 5 mm. Tension left eyeball 23 mm. Hg., right 25 mm. Hg. Left cornea appeared slightly flatter than the right. Vision, right 20/20, left 20/20. Near-point, left 11 cm., right 13 cm. Ocular movements normal. Left eye slightly elevated. Slight diminution of relative size of pupil on gazing to extreme left, with a slight increase in size on directing gaze to right. Fundi and fields normal. No disturbance of lacrymation or of vasomotor functions.

Case 4.—Pvt., Co. D, 47th Inf. Aged 30 years. Diagnosis: (1) Contusion of the spinal cord at the level of the eighth cervical and first and second thoracic segments, from machine-gun bullet. (2) Interruption of the left recurrent laryngeal nerve and of the left cervical sympathetic nerve by a piece of shrapnel.[b] Ophthalmological examination: Enophthalmos, ptosis, and myosis of left side less marked than in previous cases. Left palpebral fissure 11 mm., right 13 mm. Pupillary reactions normal, but left slower than right. Diameter left pupil 2½ mm., right 3½ mm. Under cocaine, left 2½ mm., right 4½ mm. Tension same in both eyes. Vision 20/20 in both eyes. Ocular movements normal in all directions. No change noted in the relative size of the pupils when looking to the right or the left. Fundi normal. No disturbance in lacrymation. Marked flushing on left side of face.

Case 5.—Corpl., Co. F, 26th Inf. Aged 20 years. Diagnosis: (1) Contusion of the right brachial plexus, causing temporary complete paralysis of the right arm, with a residual lesion of the seventh cervical root, causing symptoms for six months. (2) Interruption of cervical sympathetic nerve in the neck. Ophthalmological examination: Enophthalmos, ptosis, and myosis of right side. Width of right palpebral fissure 8 mm., left 10 mm. Pupils reacted to light and accommodation. Diameter of right pupil 3 mm., left 4½ mm. Under cocaine, right 3 mm., left 7 mm. Ocular movements good in all directions. Fundi negative. Vision, right 20/15, left 20/15. Unilateral anhidrosis, right side.

Case 6.—Pvt., Co. G, 28th Inf. Aged 20 years. Diagnosis: (1) Contusion of the outer cord of the right brachial plexus, causing paralysis of the right arm and shoulder of the scapulohumeral type. (2) Interruption of the right cervical sympathetic nerve in the neck. (3) Interruption of the right recurrent laryngeal nerve, causing hoarseness. Ophthalmological examination: Enophthalmos, ptosis, and myosis present on the right. Right palpebral aperture 6½ mm. Left 8½ mm. Pupillary reactions normal, pupillary measurements not recorded. Vision, right 20/50, left 20/20. Refractive error present in right eye. Fundi negative. Unilateral anhidrosis.

[a] It is probable that the oculopupillary symptoms were present immediately after the injury, but passed unnoticed, and that their onset had no relation to the operation, as stated by the patient.

[b] It is possible that the oculopupillary symptoms were in part due to the cord lesion, but the above diagnosis seems the more probable.

CASE 7.—Pvt., M. G. B., 9th Inf. Aged 28 years. Diagnosis: Contusion of right side of the spinal cord at the level of the eighth cervical segment.[a] Ophthalmological examination: Enophthalmos, ptosis and myosis of the right side. Width of right palpebral fissure 10½ mm., left 12 mm. Pupils reacted normally to light and accommodation. Size of right pupil 2½ mm., left 3 mm. Under cocaine, right 3½ mm., left 6 mm. Ocular tension, right 21 mm. Hg., left 23 mm. Hg. Vision, right, 20/20, left 20/20. Muscular excursions normal. On turning eyes to the extreme right there occurred a slight diminution in difference between the size of the two pupils, while the opposite occurred when looking to the extreme left. Fundi negative. Anhidrosis of the right side of the face.

CASE 8.—Pvt., Co. B, 11th M. G. B. Aged 29 years. Diagnosis: (1) Contusion of the spinal cord in the region of the eighth cervical segment, more on the left than the right side. (2) Contusion of left brachial plexus, mainly of the sixth, seventh, and eighth roots, with irritation. (3) Interruption of left recurrent laryngeal nerve.[b] Ophthalmological examination: Enophthalmos, ptosis and myosis of the left eye. Left palpebral fissure 9 mm., right 11 mm. Pupils reacted to light and accommodation, but left slightly more slowly than right. Diameter. left pupil 3 mm., right 3½ mm. Under cocaine, left 5½ mm., right 7 mm. Ocular tension, left 16 mm. Hg., right 17 mm. Hg. Vision, left 20/20, right 20/20 uncorrected. Left near-point 12 cm., right 16 cm. No abnormal change in the relative size of the pupils was apparent on turning the eyes to the extreme right or left. Left nictitating membrane appeared slightly more prominent than right. Fundi and fields negative. Slight diminution of sudomotor activity noted on left side of face.

CASE 9.—Pvt., Battery I, 6th Field Artillery. Aged 31 years. Diagnosis: Injury to the seventh and eighth cervical segments of the cord, mainly on the right side, causing a partial Brown-Séquard syndrome and narrowing of the right palpebral fissure. Opthalmological examination: Enophthalmos, ptosis and myosis on the right side. Right palpebral aperture 10 mm., left 11½ mm. Pupils reacted to light, accommodation, and consensually. Slight difference in activity between the two noted, the right being a little slower than the left. Diameter right pupil 3½ mm., left 4 mm. Under cocaine, right 4½ mm., left 8 mm. Tension, right eye 18 mm. Hg., left 22 mm. Hg. Vision, right eye 20/20, left eye 20/20. Right near-point 10 cm., left near-point 12 cm. Right eye slightly elevated from the normal position. Fundi normal.

CASE 10.—Pvt., Co. I, 9th Inf. Diagnosis: Contusion of the spinal cord in the region of the seventh and eighth cervical segments. Ophthalmological examination: Enophthalmos and myosis present on the left side. No ptosis noted. Width of each palpebral fissure 10 mm. Diameter of left pupil 3½ mm., right pupil 5 mm. Pupils reacted to light and accommodation, and consensually. Activity of the left slightly diminished. Tension, left eye 20 mm. Hg., right eye 25 mm. Hg. Vision, left eye 20/20, right 20/20. Near-point of left eye 13 cm., of right eye 14 cm. Muscular excursions normal. Fundi normal.

CASE 11.—Corpl., Co. E, 125th Inf. Aged 23 years. Diagnosis: (1) Partial paralysis of the right recurrent laryngeal nerve, recovering. (2) Partial interruption of the left cervical sympathetic nerve.[c] Ophthalmological examination: Enophthalmos, ptosis and slight narrowing of palpebral fissure noted on the left side. No myosis present. Left palpebral aperture 11 mm., right 12 mm. Both pupils reacted normally to light and accommodation. Each measured 3 mm in diameter, and under cocaine the dilatation was the same on either side. Vision, right and left 20/20. Ocular movements normal in all directions. Fundi negative.

A study of these cases indicates that:

(1) Low lesions, affecting the brachial plexus roots through which sympathetic fibers run, cause the most severe and typical Claude Bernard-Honer syndrome.

(2) Lesions involving the cervical sympathetic nerves, with complete or partial interruption, produce symptoms less severe, as a rule, than root injuries.

(3) Contusions of the cord result in the least pronounced phenomena, and are more prone to complete recovery than the first two conditions.

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[a] The oculopupillary symptoms may have been due to either cord contusion or actual interruption of the cervical sympathetic nerve in the neck.

[b] The oculopupillary symptoms were probably due to the contusion of the cord, but might be due to root injury, or to injury of the sympathetic nerve in the neck.

[c] This diagnosis seems probable, because the symptoms do not correspond to those found either in the group of cord contusions or of nerve lesions presumably complete.

A. RESULT OF LIQUID DIPHOSGENE GAS ONE MONTH AFTER ACCIDENT. HERNIA OF IRIS AND CILIARY BODY. DESTRUCTION OF CORNEA.

B. HOLE IN MACULA. CHOROIDAL RUPTURES.

(4) Heterochromia iridis does not occur in adults following injury to the cervical sympathetic nerve.

(5) The pupils of the cases with root and nerve injuries did not dilate with cocaine; those of the cord contusions did dilate.

(6) The near-point of the affected eye was less than that of its fellow in over 50 per cent of the cases, the average difference being slightly over 2 cm. It is difficult to draw any definite conclusion on this point, as the greatest variation was in a case of cord contusion, with only slight ocular symptoms.

INTERMITTENT EXOPHTHALMOS.

This condition, an unusual one (there are only about 60 cases on record), was observed once (Base Hospital, Camp Kearny).[2] One eye (which eye not stated) of a soldier in hospital in usual circumstances was enophthalmic. When he stooped, placing the eye in a dependent position, marked proptosis developed, associated with pain and temporary failure of vision. Hard pressure was required to reduce the exophthalmos when the eye regained its somewhat sunken state.

Study of the case seemed to demonstrate that in addition to some absorption of the orbital fat there was an enlarged venous plexus which filled as the stooping position was assumed and emptied itself as the eye was pressed into place. This explanation of the phenomenon is in accord with that usually given, the origin of the varix of the orbital veins being congenital, although commonly the venous stasis does not occur until later life.

BURNS OF EYE BY INTERMEDIATE PRODUCT IN MANUFACTURE OF DIPHOSGENE.

The destructive and also insidious action of diphosgene on the eye is illustrated in the following case:

CASE 12.—A private in the Chemical Warfare Service was admitted to Walter Reed General Hospital June 27, 1918. Owing to the breaking of tank which contained a solution of methylchloroformate intermediate in the preparation of diphosgene, some of the fluid came in contact with his right eye. At first the conjunctiva was simply red and edematous, the cornea clear, and no serious complications were apprehended; this comparatively mild reaction remained unchanged for several days. At the expiration of this period the corneal epithelium began to peel away in several places; intense cyclitis supervened; in two days the lower half of the cornea sloughed. In spite of vigorous treatment, at the end of 26 days the cornea was converted into a sloughing mass, surrounded by a densely thickened ring of tissue, while the bulbar conjunctiva was intensely inflamed. (Plate I-A.) Evisceration of the globe was performed.

Microscopic examination of the eviscerated tissue showed intense inflammation, polymorphonuclear cells predominating; also masses of extravasated blood; the stained sections contained a quantity of Gram-positive cocci.[3]

The evil consequences of these burns of the eye caused by methylchloroformate are similar to those occasioned by ammonia in that even when the original injury seems to be comparatively slight, there may develop later rapid necrosis of the cornea and all of its consequences, resulting in panophthalmitis.

PEMPHIGUS OF CONJUNCTIVA.

An unusual conjunctival affection of the left eye, originally examined in Base Hospital No. 18, A. E. F., and at first classified as pemphigus but afterwards as a form of exudative erythema, was studied later in U. S. General Hospital No. 11, Cape May, N. J.[4]

CASE 13.—The patient, a private soldier, aged 28, was admitted April 1, 1918. There was a history of relapsing inflammation of the eye of eight years' duration; the active manifestations were recurring bleb formations on the bulbar conjunctiva situated on sloughing yellowish bases, each attack lasting from a few hours to several days. When the patient was discharged (June 14, 1918) the conjunctiva showed a dry, lusterless surface and broad adhesive bands connected the palpebral and bulbar conjunctiva. General pemphigus was not present, nor were there lesions of the mouth and nose. The final diagnosis of a mild form of pemphigus with persistent and chronic course was recorded.

CONCUSSION AND CONTUSION INJURIES.

While occasionally injuries of this character occurred in the various camps and therefore the results could be studied at an early period of their existence, the majority of them concerned soldiers who had been wounded in France and who had been sent to the various eye centers in this country. Hence, the later manifestations were evident. The greater number of the cases were investigated in United States General Hospital No. 2, Fort McHenry; United States General Hospital No. 6, Fort McPherson; United States General Hospital No. 11, Cape May; and Walter Reed General Hospital. The observations may be summarized as follows: [5]

The lesions as usually noted were (1) lesions by concussion, (2) lesions by impact, and (3) combined lesions, i. e., both by concussion and impact, the lesions being in front of or adjacent to the spot of contact, and also immediately opposite to the site of impact; or, in another sense, as lesions which were not associated with, and lesions which were associated with, fracture or perforation of the orbit (passage of a missile through it). In the first case there had been concussion transmitted from a distance, or through the bony facial structures, or through the eye.

Ordinary contusion injuries naturally were not uncommon in the various camps (66 are recorded in the diagnostic tables) where at most the results were edema of the lid, diffuse redness or a patch of congestion, occasionally commotio retinæ (2 cases recorded). The type of contusion—concussion injury without especial external manifestations, or with these only slightly present, but with much vitreous hemorrhage and gross lesions of the fundus, not infrequently seen in the hospitals in France—is not definitely described in any of the reports.

The visual field changes depended upon the location of the lesion and its depth and character. Scotomas of various shapes interpreted the macular and paramacular alterations. One case of the so-called distribution-defect—that is, a field defect in addition to the local defect—was noted (United States General Hospital No. 11). This distribution defect (in conformity with the observations of Col. William Lister of the British Expeditionary Forces) was fan shaped, the expanded portion being peripheral, indicating not only damage to the spot struck but also to nerve fibers in its vicinity. The early stages of severe commotio retinæ and those of the grossly concussioned fundus with widespread clouds of hemorrhage and patches of coagulation necrosis from rupture of the choroidal and retinal vessels, were rarely seen, because for the most part the patients were examined when a considerable period of time had elapsed since the original injury; this was true also of early ruptures of the choroid and retina. Such lesions, however, at a later stage were common, and in the diagnostic tables there are of rupture of choroid 38 cases, combined rupture of the choroid and retina 29 cases, and rupture of the retina 11 cases.[a]

[a] Exactly how many of these lesions were "fresh" is not stated in the records; it is evident, however, that most of them were studied a good while subsequent to the reception of the injury.

Most important among the secondary lesions were those described as atrophic chorioretinitis; that is, spots of atrophy, exposed scleral areas and pigment distribution, heaping and fringing. The type of chorioretinitis proliferans was essentially a cicatricial process depending upon the organization of hemorrhages and the proliferation of tracts, areas, and masses of fibrous tissue.

Detachment of the retina was noted, not infrequently, independently of this type of chorioretinitis. In some instances these detachments were associated with liquefaction of the vitreous and widespread masses of yellowish-white exudation. An interesting case of this character, which developed late complications, was studied in United States General Hospital No. 2, Fort McHenry.

Case 14.—The patient had been wounded in the head, probably by a missile passing through both orbits, and the X ray showed a large fragment located near the Gasserian ganglion. In the right eye the vitreous was thickly infiltrated, the fundus difficult to see, but covered with yellowish exudation, and the retina detached below. In the left eye, over the disc and partly hiding it, there was a mass of fibrous material; otherwise no change. While under observation this left disc within two weeks developed a typical papilledema of 7 D., depending on late formation of pus in the tract of the missile.

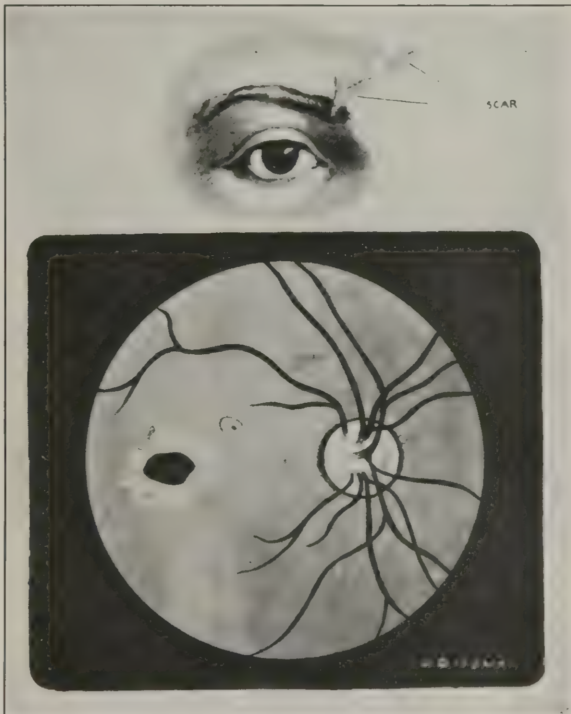

Fig. 4.—Fundus showing hole in macular region.

A number of cases of traumatic perforations of the macula lutea, commonly described as holes in the macula, were observed, sometimes as the most conspicuous fundus lesion following a concussion or impact injury, and sometimes in association with other grave changes in the eyeground—retinochoroidal ruptures, or areas of chorioretinitis. Four examples of this affection, the rest of the fundus being normal, were found in Base Hospital, Camp Sherman, and three of them were reported. The description of the lesions in two of the cases, with illustrations, follows:

Case 15.—Ophthalmoscopic examination: Right eye: Small, pin-head-sized opacity in upper central portion of lens, media otherwise clear. In the macular region is a hole, of half a disc diameter, somewhat oval in shape, with clear-cut margins. Base of hole is dark red in color, slightly lower than surrounding fundus, and has a somewhat granular appearance. Several crystals of cholesterin, and a few colloid bodies, were to be seen around the hole; also a small colloid body at nasal margin of disc. Otherwise the fundus was normal. The lesions followed a blow on the brow (see spot marked "scar"). (Fig. 4.)

CASE 16.—Ophthalmoscopic examination: Media of right eye clear. In the macular region there was an oval or pear-shaped hole, about one disc-width in length, axis horizontal, and about one-half disc in width. The base of the hole was of a dark red color, granular in appearance, and studded with minute pigmentations and crystals of cholesterin. The hole was distinctly excavated, and the margins were clear cut and well defined. Entirely surrounding the hole was a band-like area of grayish milky choroidal changes, with a prolongation of this area from its inferior level to the disc. Seven or eight good-sized crystals of cholesterin were distributed around the hole, in this area of choroiditis. Other portions of the right fundus were normal. (Fig. 5.)

A good example of typical hole in the macula, situated between choroidal ruptures, is depicted in Plate I–B. (facing p. 591).

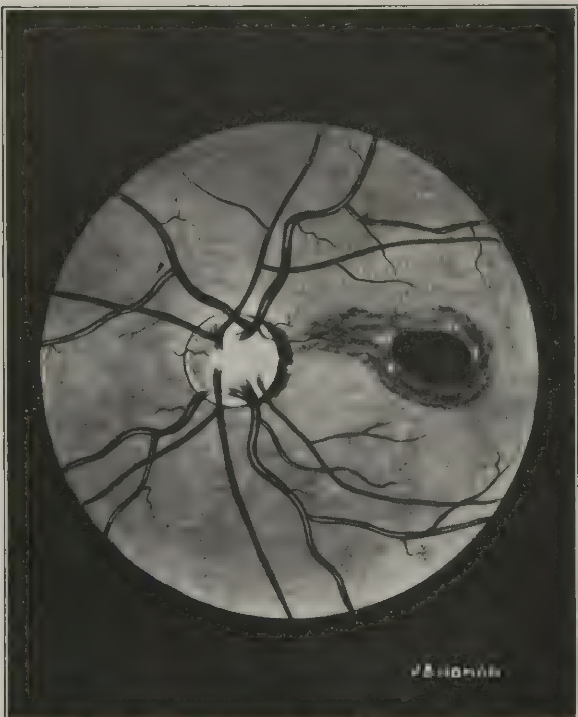

FIG. 5.—Fundus showing hole in macular region with surrounding choroiditis.

Avulsion of the optic nerve was occasionally observed. The case reported from United States General Hospital No. 11 was that of a soldier, who, as the result of a penetrating gunshot wound of the orbit, acquired this lesion. In this instance the traumatic excavation was filled with proliferated connective tissue and part of the distribution of the retinal vessels remained. (Plate II–A.)

The series of colored drawings (Plates II–B to VII) were furnished by the ophthalmic officers on duty at United States General Hospital No. 2, Fort McHenry, and depict various fundus lesions, the result of concussion and impact injuries.

OCULAR PHENOMENA IN PSYCHONEUROSES.

Although investigation of the ocular manifestations in soldiers the subjects of various types of hysteria and neurasthenia, that is, in general terms, the psychoneuroses, was made in a number of the eye services, the chief studies in this respect took place in United States General Hospital No. 30, Plattsburg Barracks, and concerned themselves especially with 44 cases. Of these 44 cases, 35 belonged definitely to the neurotic group; the remainder (9 cases) to the organic group, that is, the patients exhibited optic nerve atrophy (2 cases), optic neuritis (3 cases), palsy of exterior of ocular muscles (4 cases).

Although some of the men developed nervous phenomena as the result of exposure to shell fire, or when they had been in the vicinity of exploding shells and were in that sense shell-shocked, others had not had this experience; their symptoms, however, exactly similar to those of the other group, were due to war shock. Excluding those, a comparatively small percentage, who

A. AVULSION OF THE OPTIC NERVE FOLLOWING GUNSHOT WOUND OF THE ORBIT. TRAUMATIC EXCAVATION FILLED IN WITH PROLIFERATIVE CONNECTIVE TISSUE.

B. LARGE CRESCENTIC SCAR (CHOROIDAL RUPTURE), CONCENTRIC WITH DISC MARGIN BETWEEN DISC AND MACULA.

A. HOLE IN THE FOVEA AND CENTRAL RETINOCHOROIDITIS FOLLOWING BLOW BY FIST ON RIGHT EYE.

B. MACULAR RETINOCHOROIDITIS.

A. CHORIORETINAL ATROPHY AND HOLE IN RETINA FOLLOWING SHELL WOUND OF FACE, WITH LOSS OF RIGHT EYE.

B. WIDE RUPTURE OF CHOROID AND RETINA OF UNUSUAL SHAPE. . PARTIAL ATROPHY OF DISC.

A. CRESCENTIC RUPTURE OF CHOROID CAUSED BY BLOW ON LEFT EYE WITH BOTTLE.

B. WIDE RETINOCHOROIDAL RUPTURES, PIGMENT WIDESPREAD AND HOLES IN MACULA, FOLLOWING GUNSHOT WOUND THROUGH INNER CANALICULUS OF LEFT LOWER EYELID.

MACULAR ATROPHIC PIGMENTED RETINOCHOROIDITIS AND PIGMENT SURROUNDING DISC, DUE TO EXPLOSION OF AMMUNITION DUMP.

A. WIDESPREAD GRANULAR PIGMENTATION (TRAUMATIC PIGMENTED CHOROIDITIS), AND TWO BRANCHING RETINOCHOROIDAL RUPTURES.

B. RIGHT FUNDUS OF PATIENT WHOSE LEFT EYE GROUND IS SHOWN ABOVE. ELABORATE PROLIFERATED MASSES OF CONNECTIVE TISSUE FRINGED WITH SPIKED AREAS OF PIGMENT. AVULSION OF OPTIC NERVE. COMPLETE ABSENCE OF VESSELS.

had developed symptoms indicative of true brain concussion, the remainder exhibited a neurosis of the neurasthenic or psychasthenic type or hysteria.[6]

It is not useful, indeed not possible, to attempt to distinguish between the visual phenomena of those who were purely hysteric and of those who were neurasthenic or psychasthenic, as has sometimes been done in studies made in civilian practice.

The ocular symptoms of the functional group (nine members excluded who did not exhibit any disturbances of their eyes or eye functions) included: (1) Various types of amblyopia and amaurosis; (2) anomalies of color vision and of the limits of the visual fields; (3) asthenopias and defects of accommodation; (4) anomalies of the exterior eye muscle movements.

The defects of direct vision (unimproved by correction of refractive error and unassociated with fundus lesions) varied in degree from moderate reduction as measured with type cards to uncertain object perception, and, according either to the history of the case or to observation, had been transitory, lasting a few minutes, enduring, lasting from several hours to two weeks; and long-enduring, lasting for months. All patients examined had acquired their neurotic disturbances a considerable period antedating the time of examination, generally but not always, in service overseas.

Of the visual field disturbances, usually readily suggestible, all of the common varieties were observed: Concentric contraction; contraction with inversion of the color lines, the so-called fatigue spirals, and tubular contraction. Complete color blindness (one case) was also noted. Anomalies of accommodation, i. e., weakness of the amplitude of accommodation and spasm of accommodation, were observed, the former being a common condition.

The ocular muscle palsies in all cases examined were evidently of organic origin, that is, no instances of the so-called hysteric eye muscle palsies were discovered. True nystagmus as an hysteric ocular sign was not observed. Very frequently nystagmoid movements could be developed in forced rotation of the eyes in the lateral direction. A curious speech defect was evident in many of these war neurotics, not exactly a stuttering, but a repetition of a single word or brief sentence; for example, the soldier would say: "I was shocked, I was shocked, I was shocked, in the, in the, in the, in the Argonne." Sometimes these repetitions were many in number, half a dozen or more, before the final word of the sentence was reached. Almost always there was an associated trembling of the lips and general tremor, and almost invariably, if these patients were made to turn their eyes sharply to the right or left, a jerking nystagmic movement was developed. In other words, it was a species of tremor.

Unequal width of the palpebral fissure was noted several times, and one case of exophthalmos associated with a gait resembling cerebellar ataxia. Blepharospasm, both tonic and clonic, was observed sometimes associated with photophobia, contracted fields, and ciliary spasm, a well-recognized syndrome in these circumstances. An example of long-enduring blindness, or partial blindness, is the following:

Case 17.—A colored soldier, aged 20, with a service of one year, part of which (from April, 1918, to November, 1918) was in France, while engaged in laying rails, began to complain of painful and inflamed eyes, which steadily grew worse as he was sent from one camp hospital to another,

until finally he was returned to this country. There was no history of shell shock in the ordinary sense of that term, but what may have been a slight conjunctivitis furnished the suggestion of an escape from an intolerable situation. The records state that his vision was respectively 6/200 and 4/200, but when he was examined in December, 1918, it was not nearly equivalent to that amount, being at best object perception, and that uncertainly. Except for a moderate clonic blepharospasm and the blindness, his eyes and eye movements were normal in all respects. The records state that he stumbled over objects placed before him. He exhibited an almost constant general tremor and was excessively nervous. Called from the hall into the examining room, he came with the hesitating step of a blind person, failing to avoid objects in the room, and once walked into a small metal chair, which, striking the floor, made a crashing noise that sent him into a fit of trembling so violent that it simulated a general convulsive seizure. He was not a malingerer (he was closely watched for a long time) and suffered real mental distress. After one month of treatment by suggestion, aided with electricity, he made a complete recovery in all respects. The first visual field obtainable was extremely concentrically contracted, and day by day widened until it assumed a fully normal extent. His period of blindness, therefore, lasted approximately eight months. (Figs. 6–9.)

The following case history of a war neurotic, but not a shell-shocked one, illustrates how suggestion determined the symptoms of reduced acuteness of sight, and also how they were removed through the same channel:[a]

Case 18.—A simple-minded recruit from the mountain regions of the southwest had been told by some traveling "eye doctor" during the period of his few months of schooling that his eyes were weak and needed glasses. Bewildered by the strange surroundings of a training camp, backward in the acquisition of his duties, unmercifully "ragged" by his comrades, knowing that replacements for overseas work were being rapidly formed, dreading his inferiority because of supposed weak eyes, alarmed by cruel stories of the horrors of foreign warfare, he developed a typical neurosis, the prominent symptoms being tremor, whispering voice, and amblyopia, the visual acuteness being reduced to less than one-tenth of normal. At first all attempts to improve the vision, although the eyes were perfectly healthy, were fruitless. The suggestion gently but insistently made that spectacles would restore the lost quota of sight and put him on an equality with those who possessed normal vision, with whom he would surely have to go, stimulated the instinct of self-preservation and vision became absolutely normal through glasses of negative refractive power. In the first instance he released himself from an intolerable situation by the development of a defect suggested by the eyes, and in the second place relieved himself from an anticipated situation more intolerable than the first one by putting himself on equality with his comrades in the game of self-preservation, the restoration of vision suggesting the method of release.

The following case history illustrates one of the forms of so-called hysteric color-blindness:[b]

Case 19.—A boy, aged 18, well educated, had the position of flag boy on a transport, the duties of which he well and accurately performed. Suddenly one morning, when the ship was about entering the submarine zone, and the natural activities of the ship life were exceedingly acute, he announced to the supervising officer that he was no longer able to distinguish the colors. It had been noted he was apprehensive and restless for some little time before this announcement was made. He was immediately sent to the sick bay and examined. Functional testing of his eyes produced normal results in every respect, except that he was totally color-blind. He was kept in the ward for a few days, and little by little apparently was helped by reassuring statements which were made to him, not only in regard to the return of color perception but to the safety of his position, his ability to recognize the colors returned, and was ultimately entirely reestablished. The temporary color-blindness in this patient interpreted an anxiety reaction. The boy had, preceding his sudden loss of color perception, a period of great anxiety, which increased as the transport entered or was about to enter the danger zone, and he overestimated his own responsibilities and feared that his duties improperly performed might bring the whole ship's company into great danger. The loss of color sensation, considering his occupation and his anxiety, was subconsciously adopted as the means to escape from the intolerable situation.

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[a] Personal observation in School of Ophthalmology, M. O. T. C., Camp Greenleaf, Fort Oglethorpe, Ga.

[b] This observation, a personal one, was made not in any of the camp hospitals but on an American transport.

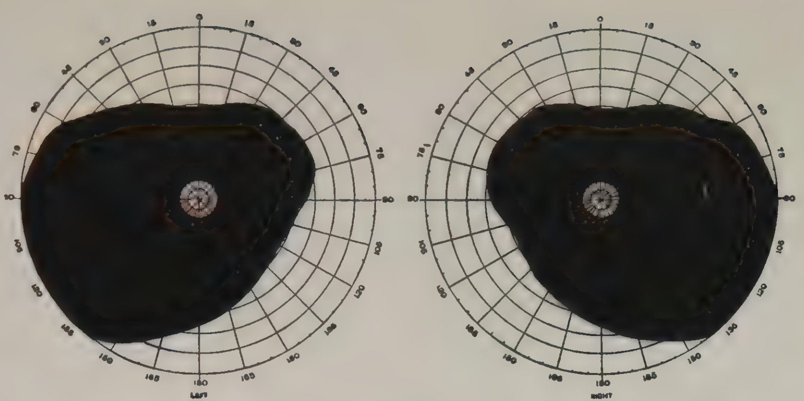


FIG. 6

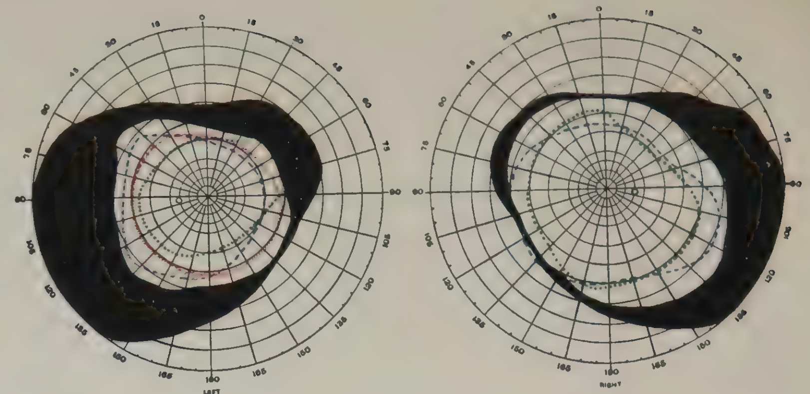


FIG. 8.

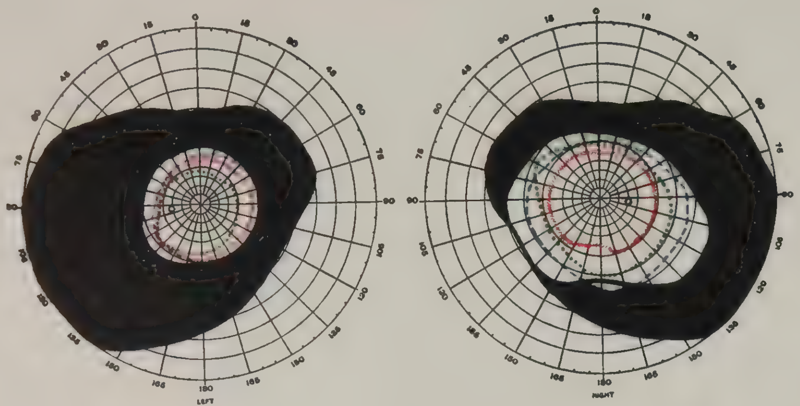


FIG. 7.

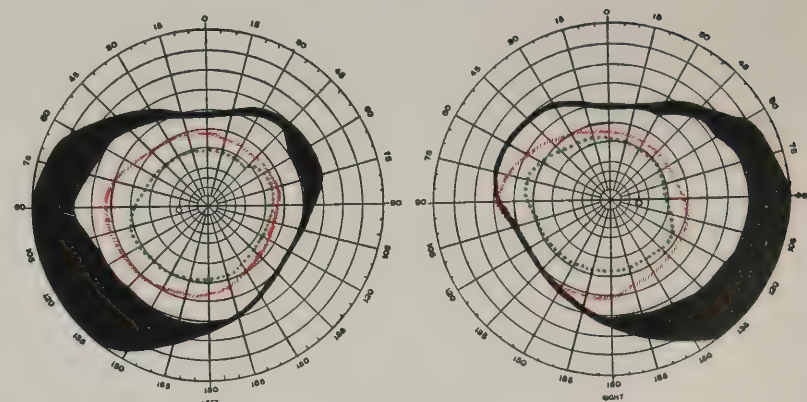


FIG. 9.

FIGS. 6–9. Hysterical amblyopia lasting eight months.
FIG. 6 typical tubular field. FIGS. 7–9 show gradual increase in size of field, easily brought about by suggestion.

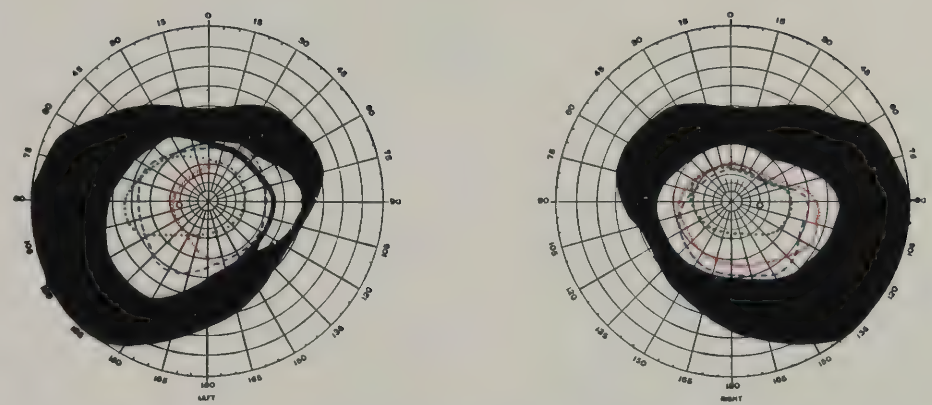


FIG. 10.

War shock and hysteria. Familiar contraction of field and partial inversion of color lines. Patient highly suggestible, V. $\frac{20}{L}$.

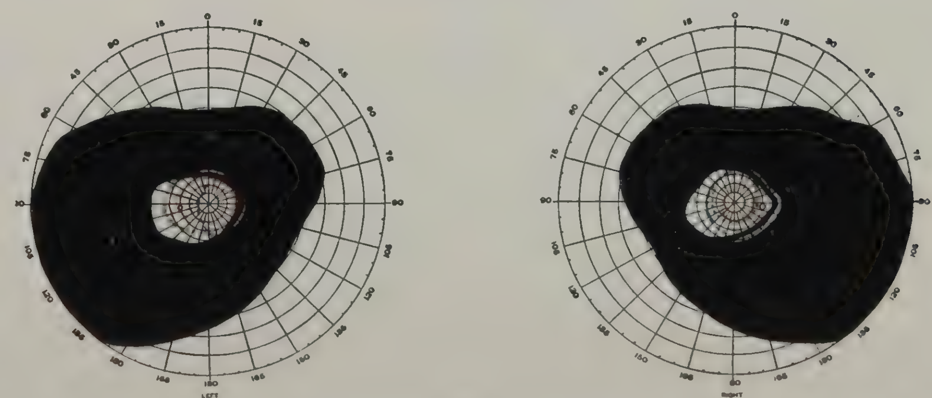


FIG. 11.

War shock and hysteria. Concentric contraction and color inversion. Note that red occupies in right field the smaller area. Patient highly suggestible.

Figures 10 and 11 depicting visual charts, selected from a number mapped in United States General Hospital No. 30, Plattsburg Barracks, illustrate common anomalies found in the examination of war neurotics—that is, concentric contraction, inversion of the color lines, and so-called tubular fields—the patients concerned being highly suggestible.

VISUAL DEFECTS CAUSED BY OCCIPITAL LOBE LESIONS.

The past war afforded unusual opportunities for observation of the visual functions in their relation to more or less circumscribed lesions of the brain.

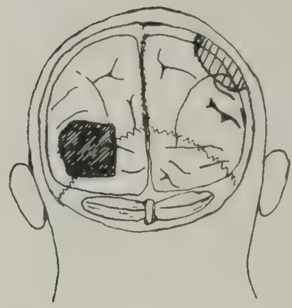
A number of soldiers from the American Expeditionary Forces, entered in various eye centers in the United States, belong to this group, and the following report in illustration of such conditions is the result of studies made in United States General Hospital No. 11, at Cape May.[7] It concerns itself with an investigation of 13 patients, each one of whom had received a head wound which involved one or both occipital lobes. In each of three cases (20, 23, 26) a foreign body had traversed the brain for a considerable distance, in two instances (20 and 26) passing from one hemisphere to the other across the median line. In cases 24 and 26 the X ray revealed projectiles in the substance of the brain near the opposite side of the cranium from the points of entrance. In Case 20 there was evidence that a projectile had been removed by early operation at a distance from the wound of entry. In several cases small fragments of bone were revealed within the cranial cavity near the defect in the skull.

While none of the cases of this series came to necropsy, and it was impossible to determine with accuracy the extent of the brain injuries, it is of some interest to observe the correlation of the visual defects and the brain lesions.

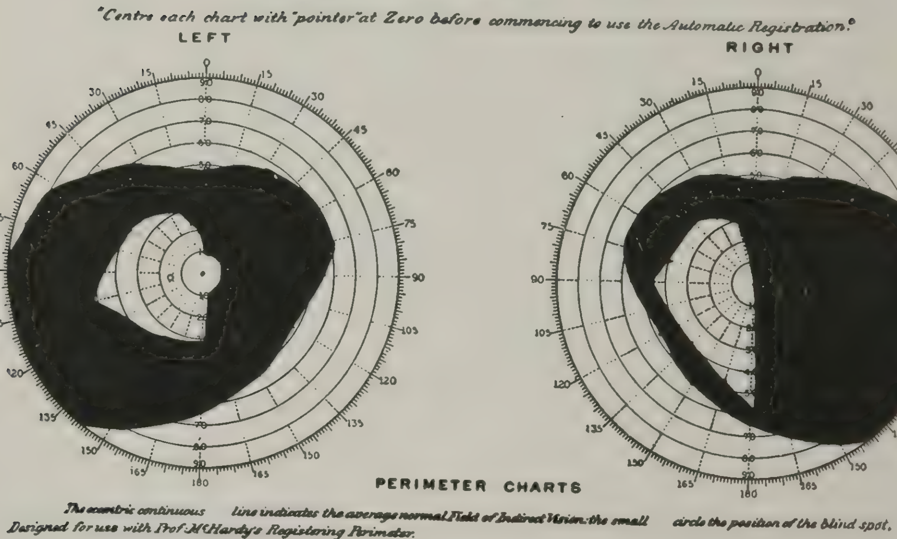
In charting the fields a self-registering perimeter was used to determine the peripheral fields, and an improvised screen similar to the Bjerrum screen for the purpose of mapping more accurately visual defects of the central areas. Using an object 5 mm. square, and with the patient at a distance of one meter from the screen, defects in the central areas may be recorded with a margin of error of less than one degree.

The illustrations showing the position of cranial defects and of foreign bodies are based upon tracings from radiographs. Conventional diagrams of the cranium, that of the lateral aspect modified from Marie and Foix, and of the posterior aspect from Wilbrand and Sänger, are utilized, depicting the bony landmarks in relation to those of the cerebral cortex. The close approximation of the posterior poles of the occipital lobes to the external occipital protuberance is particularly to be noted.

CASE 20.—P. B., 26 years. Wounded September 27, 1918, in left occipital region; unconscious for several hours; early operation, details unknown. Paralyzed in left arm and leg for two or three months. Admitted to General Hospital No. 11, March 13, 1919. X-ray findings: Cranial defect in left occipitoparietal region (Fig. 12); small metallic fragment near the midline intracranially; trephine holes and the outlines of a bone flap in the right parietal bone. There was a trace of a residual left hemiplegia and a right homonymous hemianopsia. Eye movements, pupils, and fundi were normal. Fixation retained. Visual acuity, O. D. 20/15, O. S. 20/20. The field charts



Case No. 20, P.B. Left Parieto-Occipital wound and Cranial defect. Right parietal bone flap. Right homonymous hemianopsia.



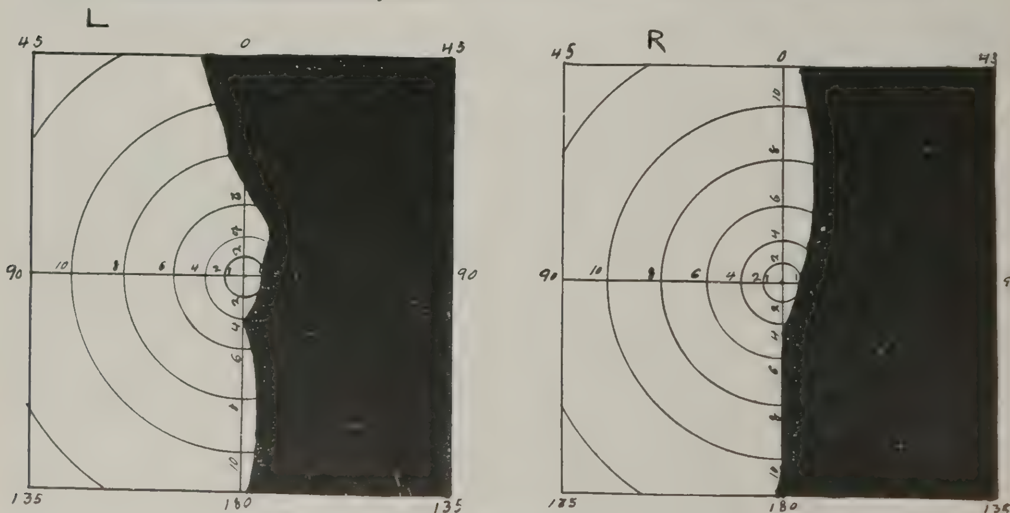


FIG. 12.

(Fig. 12) show the blind areas extending to within less than one degree of the fixation point and about the same distance from the midlines in the upper halves of the fields. In this case evidence justifies the conclusion that a projectile entered left occipital region at the site of the cranial defect, passing upward, forward, and to the right, lodging in the right parietal region, from whence it was removed by an early operation.

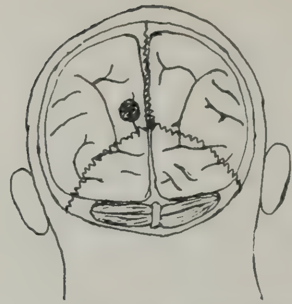
Case 21.—W. C., 25 years. Wounded September 29, 1918, by shell fragment in the left posterior parietal region near the midline. Was unconscious for about five minutes; no record of early operation. Admitted to General Hospital No. 11, March 10, 1919, with unhealed wound. X ray showed a cranial defect 2 cm. in diameter near posterosuperior angle of the left parietal bone (Fig. 13); also numerous small bone fragments near the margins of the defect and a small metallic foreign body 2 cm. downward from the inner table. Homonymous hemianopsia constituted the only focal symptom of cerebral injury. Ocular movements, pupils, and fundi were normal. Fixation retained. Visual acuity, O. D. 20/20, O. S. 20/20. Field charts made with a 5 mm. test object show homonymous hemianopsia extending to within one-half degree of fixation points. (Fig. 13.) Tests made with bright lights and large moving objects revealed a slight degree of retained vision throughout the affected fields. From the location of the cranial defect and the relative position of metallic and bone fragments, it is apparent that the cerebral lesion involved the left occipital lobe near the upper margin at a considerable distance from the occipital pole. The destructive effect of the wound was evidently downward toward the optic radiations of Gratiolet.

Case 22.—F. C. B., 23 years. Was wounded November 1, 1918, in right occipital region; unconscious for one-half hour; no record of early operation. Wound healed in February, 1919; admission to General Hospital No. 11, March 7, 1919. X ray showed cranial defect 5 cm. in diameter involving the right occipitoparietal suture. (Fig. 14.) Numerous small bone fragments in the vicinity of the defect. Left homonymous hemianopsia was the only focal cerebral symptom observed. Ocular movements and pupils were normal; both fundi showed slightly blurred disc margins. Visual acuity, O. D. 20/20, O. S. 20/20. Fixation retained. Charts show hemianopsia fields extending to within one-fourth degree of the fixation points. (Fig. 14.)

Case 23.—J. B., 24 years. Received multiple wounds in shoulder and back from a bursting shell on June 13, 1918; wounded a second time on November 3, 1918, a piece of metal passing through the right orbit and lodging in the right temporal muscle without penetrating the cranium. The right eye was enucleated. There was no record of any occipital wound. This patient was admitted to General Hospital No. 11, February 20, 1919. X-ray findings: (*a*) A metallic foreign body, $1\frac{1}{2}$ cm. in diameter, in the right temporal muscle above the zygoma; (*b*) a cranial defect 2 cm. in diameter in the occipital bone 1 cm. to the right and 1 cm. above the external occipital protuberance. The extra-ocular movements, pupil, and fundus of the remaining left eye were normal. The field chart shows a left hemianopsia extending practically to the fixation point. Visual acuity 20/30. Although the patient was unaware of the occipital wound, and the history contained no record of it, circumstances indicate that it occurred on June 13, together with the multiple wounds of the back and shoulder. If that surmise is correct, this soldier returned to duty with an unrecognized homonymous hemianopsia. (Fig. 15.)

Case 24.—G. C., 31 years. Wounded November 3, 1918, in left occipital region near the external protuberance. No record of early operation. Transferred to General Hospital No. 11, December 28, 1918; under observation for nine months. On admission the following conditions were noted: Marked right hemiplegia, complete aphasia, and right homonymous hemianopsia. The hemiplegia gradually receded to a slight residual remnant. Speech and the comprehension of spoken language were in large measure regained; almost complete alexia persisted. The hemianopsia was complete and permanent. X-ray findings: (*a*) A cranial defect 1 by $\frac{3}{4}$ cm., 1 cm. above the inion, bordering the midline; (*b*) a metallic foreign body in the frontal region close to the midline about 3 cm. under the coronal suture. (Fig. 16.) Ocular movements and pupils were normal. Fundi were negative except that left disc margin was blurred. Fixation retained. Visual acuity, O. D. 20/20, O. S. 20/20. Charts of the macular areas show the blind fields extending to within two-thirds of a degree of the fixation point. (Fig. 16.)

Case 25.—A. D., 25 years. No details of the early history of this case were available. X-ray findings: Large irregular cranial defect, 4 by 8 cm., involving the left occipital and parietal bones, and bordering on the midline. (Fig. 17.) Ocular movements, pupils, and fundi were normal;



Case No. 21, W.C. Wound and cranial defect in
left posterior superior parietal region.
Incomplete right homonymous hemianopsia.

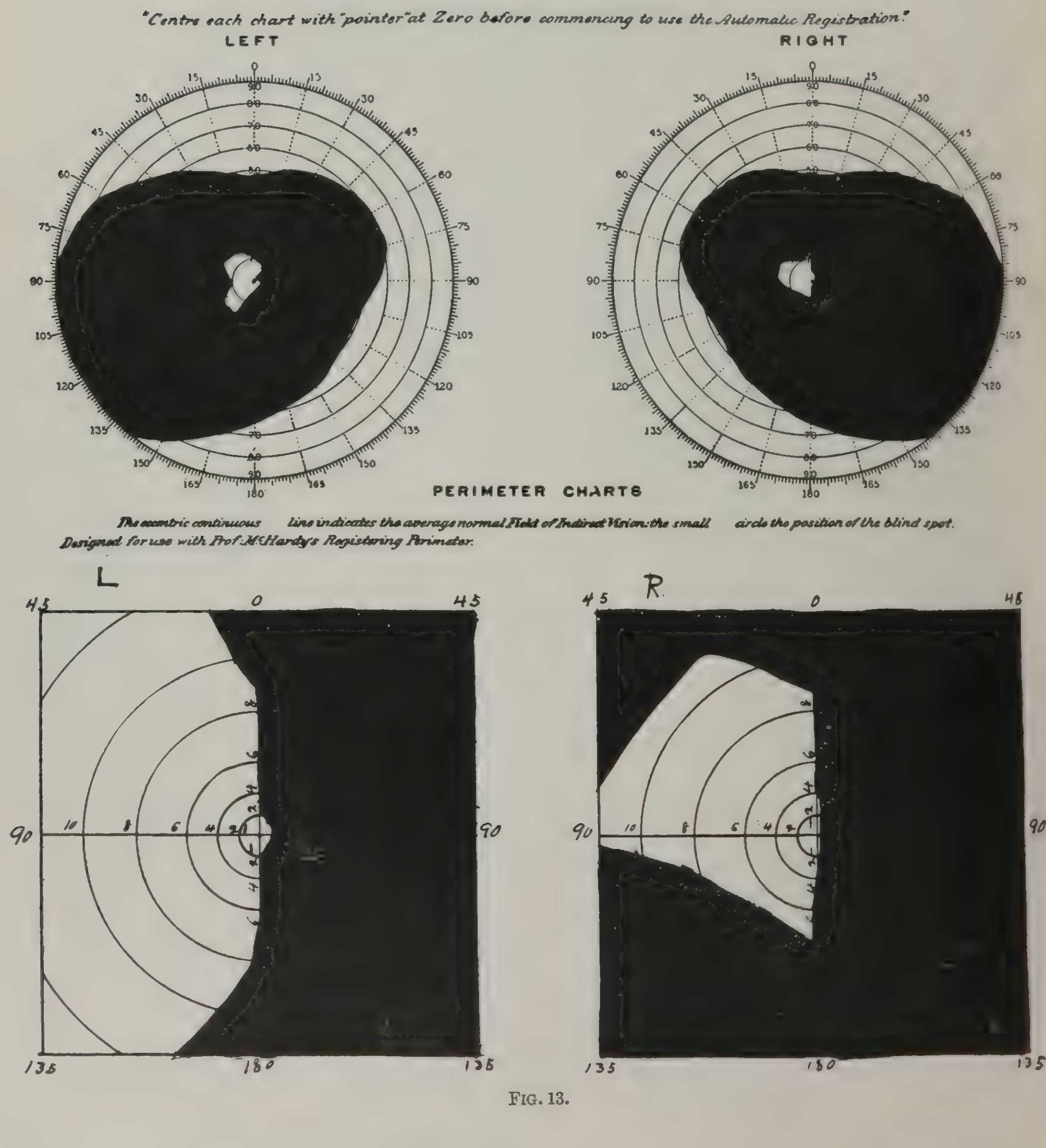
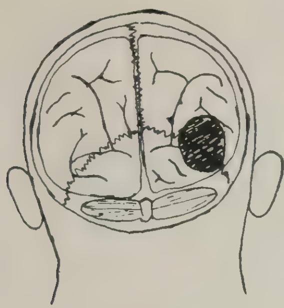
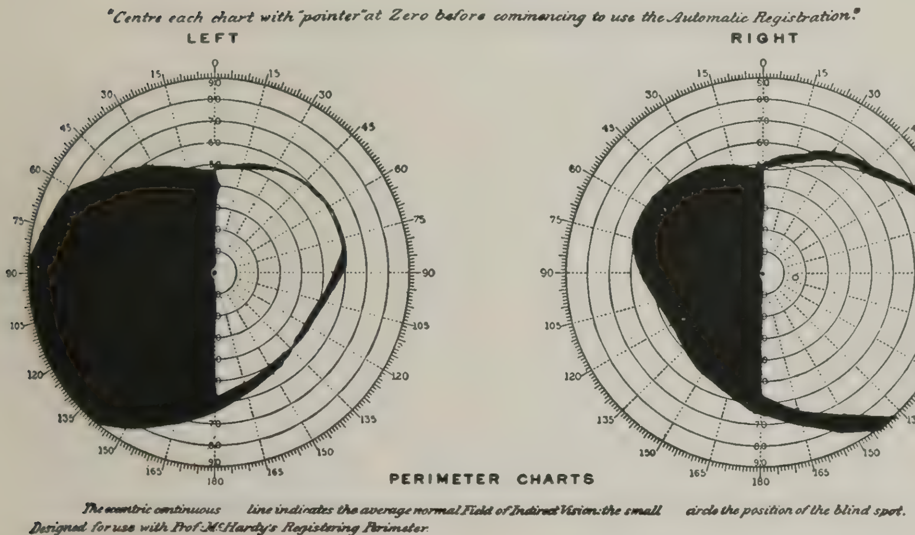


FIG. 13.



Case No. 22, F.C.B. Wound and defect in right parieto-occipital region. Left hemianopsia.



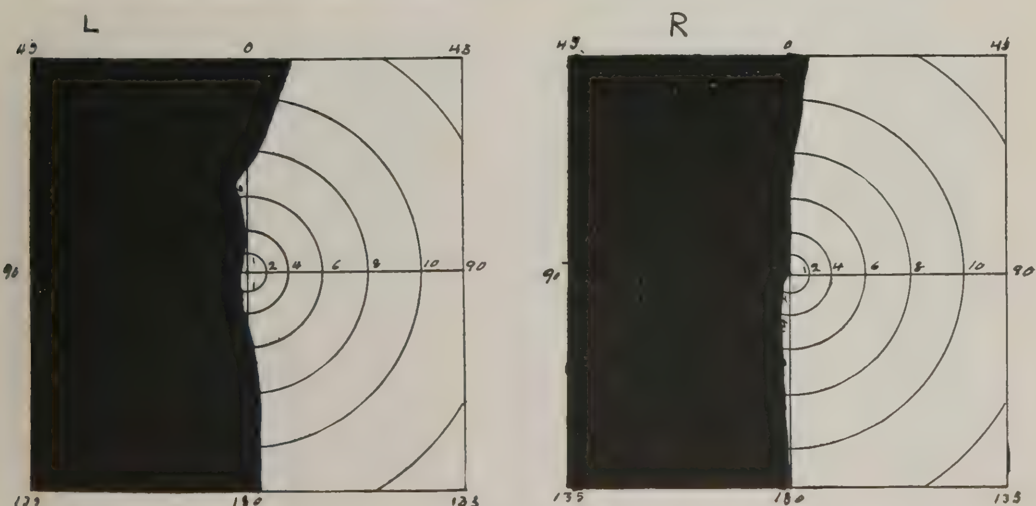
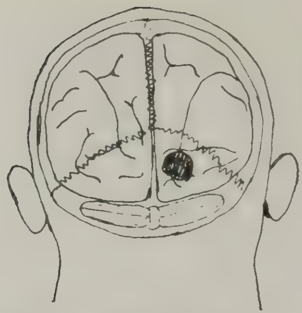
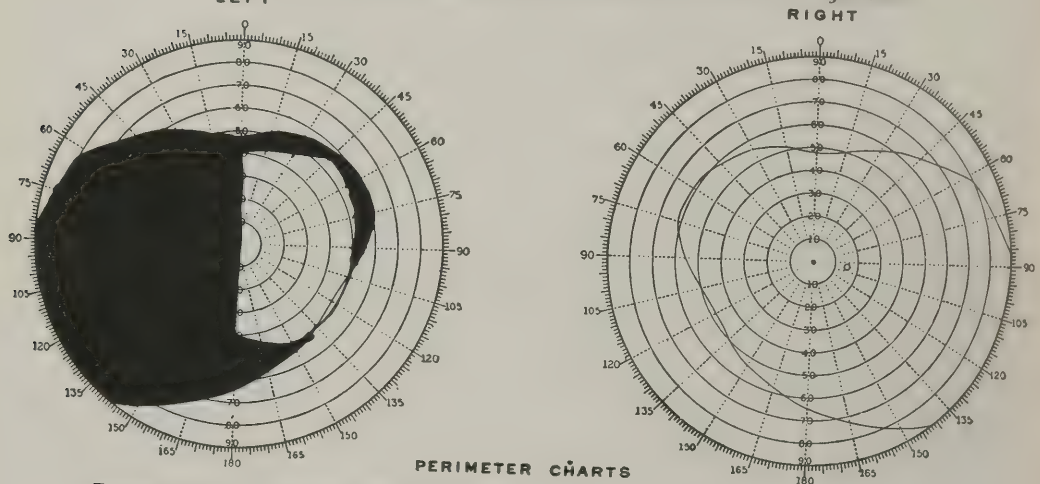


FIG. 14.



Case No. 23, J.B. Right occipital wound and defect.
Left hemianopsia.

"Centre each chart with "pointer" at Zero before commencing to use the Automatic Registration."



PERIMETER CHARTS

The eccentric continuous line indicates the average normal Field of Indirect Vision: the small circle the position of the blind spot.
Designed for use with Prof. McHardy's Registering Perimeter.

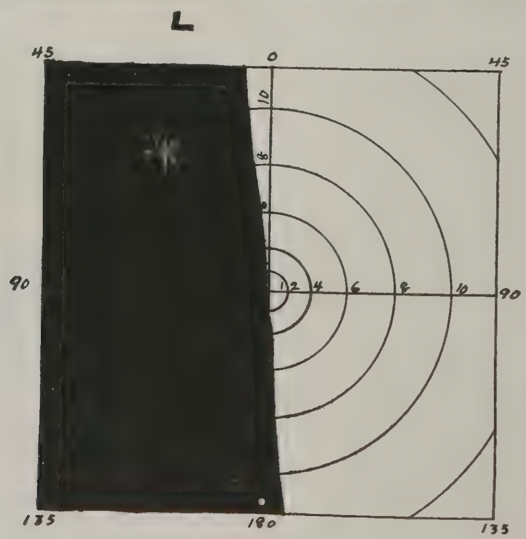
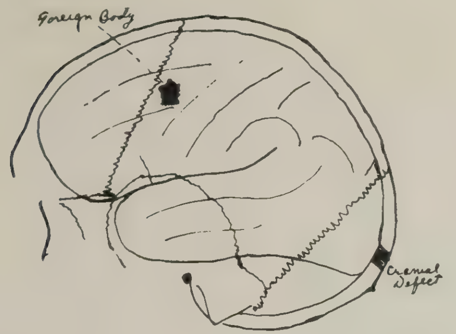
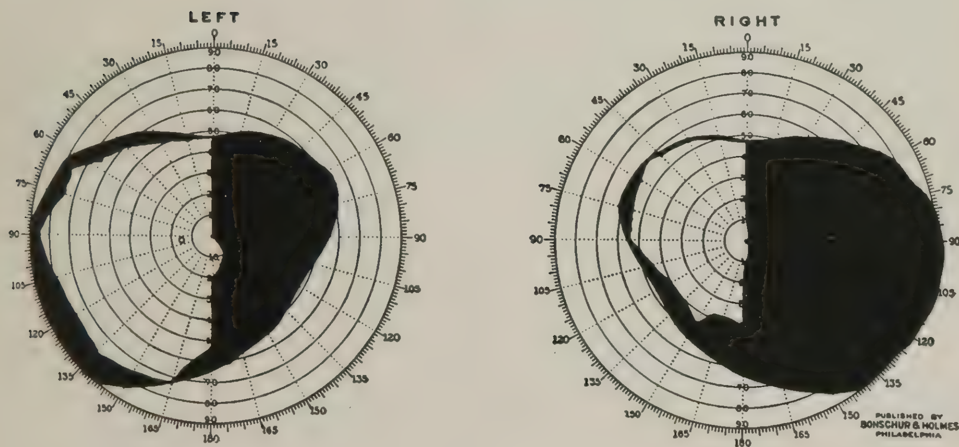


FIG. 15.



Case No. 24, G.C. Left occipital wound and defect near inion. Metallic foreign body in frontal region close to midline. Right hemianopsia, alexia, Transient right hemiplegia and complete aphasia.



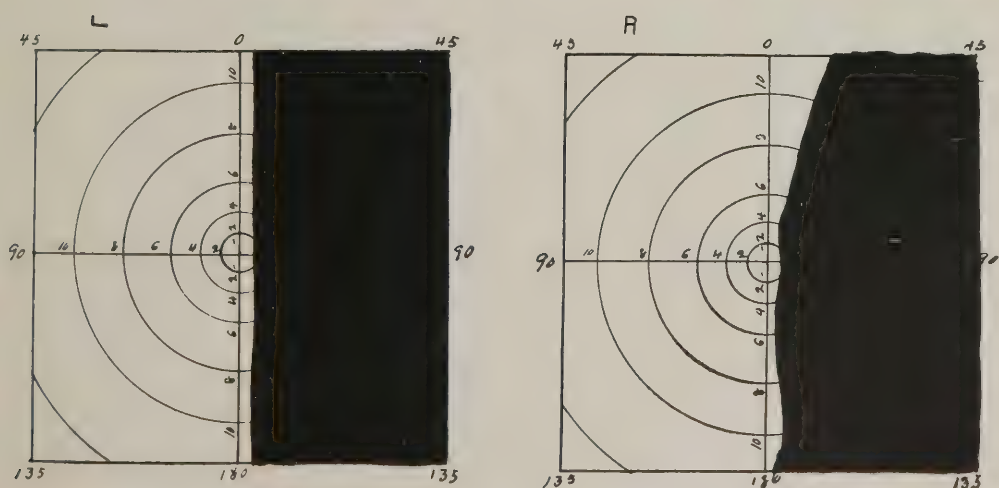


FIG. 16.

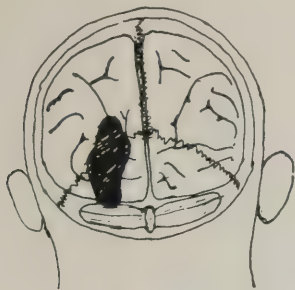
slight haziness of the lens of the right eye. Visual acuity, O. D. 20/100, O. S. 20/15. Right homonymous hemianopsia extending to the fixation points. (Fig. 17.)

CASE 26.—M. D., 24 years. Early records of this patient were not available, and he was unable to give details on account of the memory defect. He was ambulatory, with evidences of a very slight residual left hemiparesis; mentally confused and amnesic. He had difficulty at first in finding his bed, and was frequently lost in the corridors of the hospital. Gross intelligence defect. X-ray findings: (a) Cranial defect 3 cm. in diameter in the right frontal region; (b) metallic foreign body about the size and shape of a machine-gun bullet in the left occipital region 2 cm. from the inner plate of the occipital bone, 3 cm. to the left of the midline, and 1 cm. above the level of the inion. Ocular movements, pupils, and fundi were normal. Visual acuity, O. D. 20/50, O. S. 20/50. Left homonymous hemianopsia extending to within 5 degrees of the fixation point. (Fig. 18.) From the X-ray evidence, the foreign body is apparently lodged just posterior to the posterior horn of the lateral ventricle. Its probable course may be assumed to extend from the frontal defect downward, backward, and to the left across the midline. The right corona radiata was traversed, as was the posterior part of the corpus callosum. The optic radiations of the left occipital lobe were involved, but those of the right occipital lobe were evidently beneath the tract of the projectile.

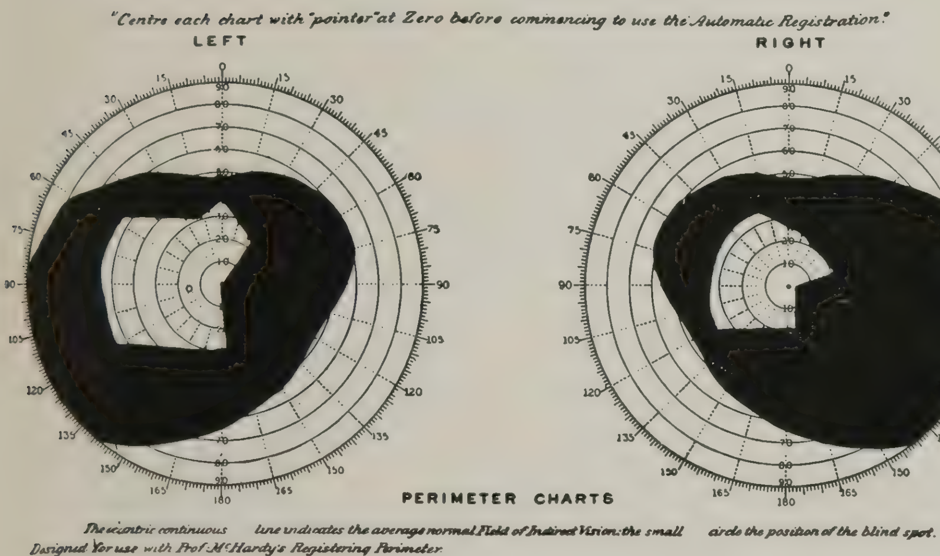
CASE 27.—F. D., 26 years. Wounded October 28, 1918, in the right occipital region. He was unconscious for 10 hours, and on waking everything seemed blurred. Early operation, local anesthesia, removal of bone fragments and pulped brain tissue. No foreign body; wound closed without drain. Admitted to General Hospital No. 11, April 3, 1919, ambulatory. X-ray findings: Cranial defect 3 by 4 cm. in occipital bone bordering the right lambdoidal suture, and several small bone fragments down and in from the defect. Ocular movements normal; pupils equal and reflexes were present but the left a little sluggish. Vessels of both fundi were tortuous, discs sharply defined; physiologic cup obliterated on the right and small on the left. Visual acuity O. D. 20/15, O. S. 20/15. Left homonymous hemianopsia extending to the fixation points. (Fig. 19.)

CASE 28.—L. S., 29 years. Wounded October 12, 1918, in the left occipital region; early operation. Admitted to General Hospital No. 11, January 4, 1919; under observation six months. X ray showed a defect 5 by 6 cm. in the left occipital region bordering the midline. An operation for the repair of the cranial defect was performed March 15, 1919. A cone-shaped fluid-filled cavity was encountered the apex of which communicated with the posterior horn of the left lateral ventricle, the base coinciding with the margins of the cranial defect. A considerable quantity of cerebrospinal fluid escaped, and the X-ray picture taken immediately after the operation showed the outline of the air-filled lateral ventricle. (Fig. 20.) Ocular movements normal; slight convergence of the right eye. Pupils equal and reflexes present; media clear; no significant fundus changes. Visual acuity O. D. 20/50, O. S. 20/30. Complete right homonymous hemianopsia, and very defective left fields. (Fig. 20.) Macular vision was preserved in a semicircular area extending from a vertical line through the fixation point into the left fields one and one-half degrees. Roughly symmetrical islands of retained vision were present in the left fields, but distinctly separated from the maculæ. To study the hemianopsia in relation to the fixation points tests were made at a distance of five meters from the patient with a white object 5 mm. in diameter. At this distance and with steady fixation the object was seen only when it approached within 1 cm. on the right side of the fixation point on testing the right eye, and within less than 2 cm. when testing the left eye. These tests were repeated on different days, and the results were always definite and consistent.

CASE 29.—B. H. Wounded October 4, 1918, in the right occipitoparietal region. In No Man's Land for two days. Unconscious for two weeks. Early operation. Admitted to General Hospital No. 11, December 22, 1918, with unhealed wound. X ray showed a large cranial defect, 4 by 8 cm., involving the right side of the occipital and the right parietal bones. (Fig. 21.) Ocular movements, pupils, media, and fundi were normal. Fixation retained, visual acuity O. D. 20/40, O. S. 20/40. Macular vision only was preserved, with the exception of the perception of bright light and large moving objects in part of the right fields. The retained macular areas were roughly cone shaped and symmetrical, extending from a semicircular line through the one degree point on the left of the fixation point of the right eye, and the one-fourth degree of the left eye toward the right for about two degrees. (Fig. 21.)



Case No. 25, A.D. Left Parieto-occipital wound and defect. Right hemianopsia.



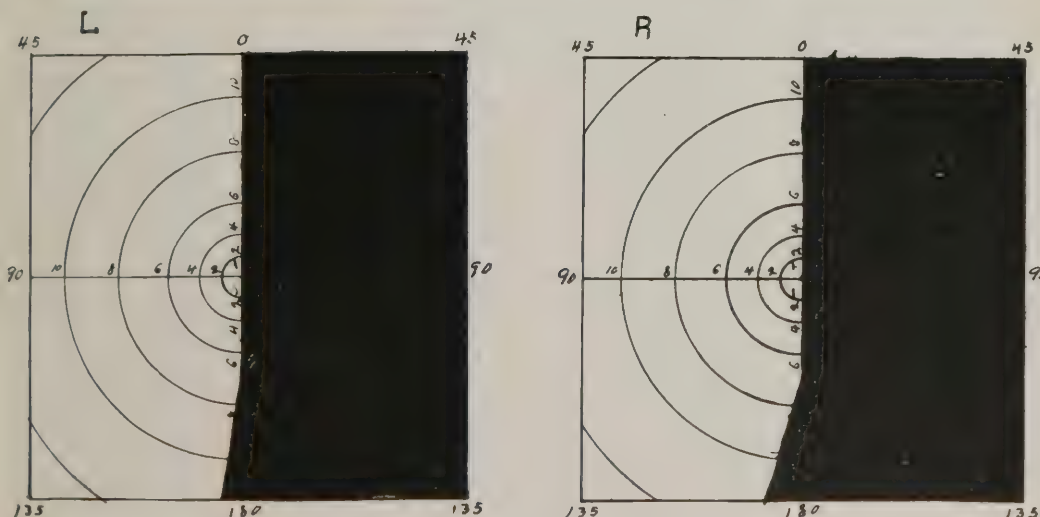
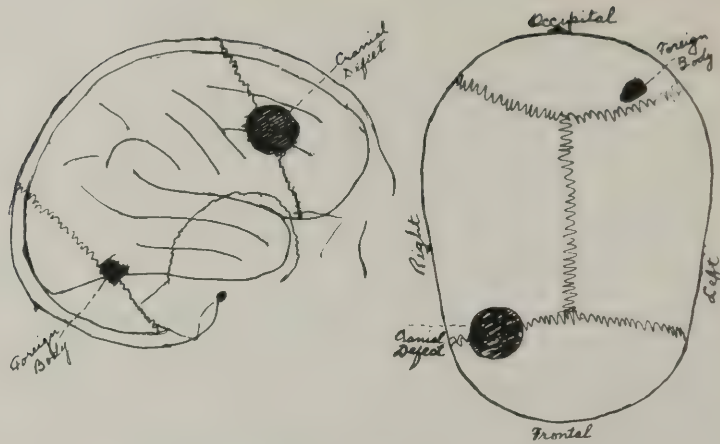


FIG. 17



Case No. 26 M.D. Right fronto-parietal wound and defect. Foreign body in left occipital lobe. Right hemianopsia, dementia.

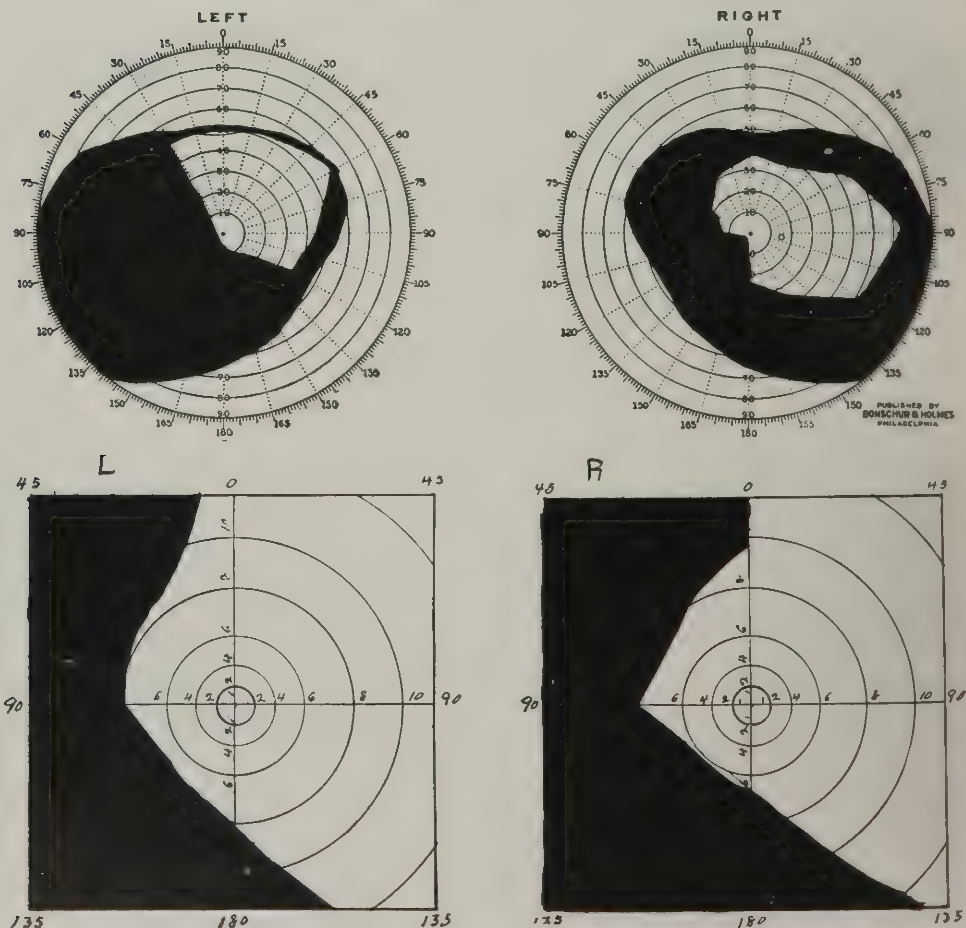
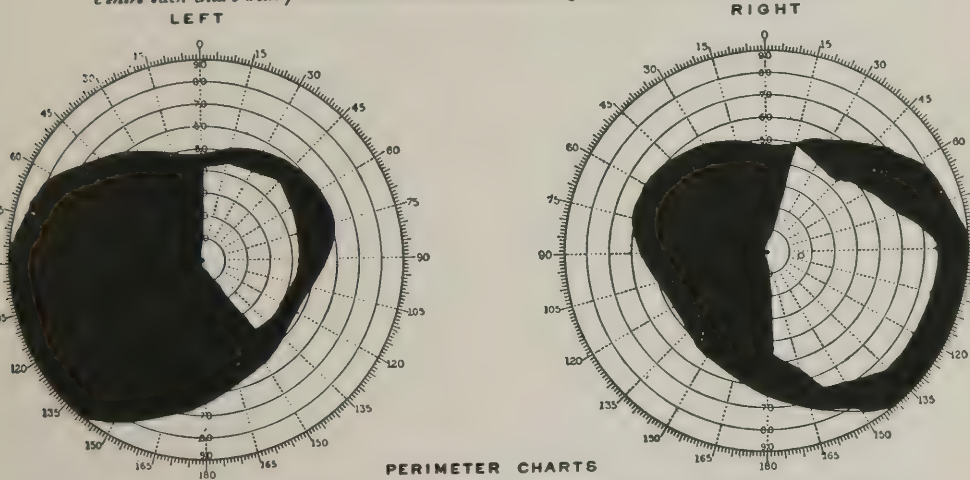


FIG. 18.

Case No. 27, F.D. Right occipital wound and defect.
Left hemianopsia.

"Centre each chart with "pointer" at Zero before commencing to use the Automatic Registration."



PERIMETER CHARTS

The eccentric continuous line indicates the average normal Field of Indirect Vision: the small circle the position of the blind spot.
Designed for use with Prof: McHardy's Registering Perimeter.

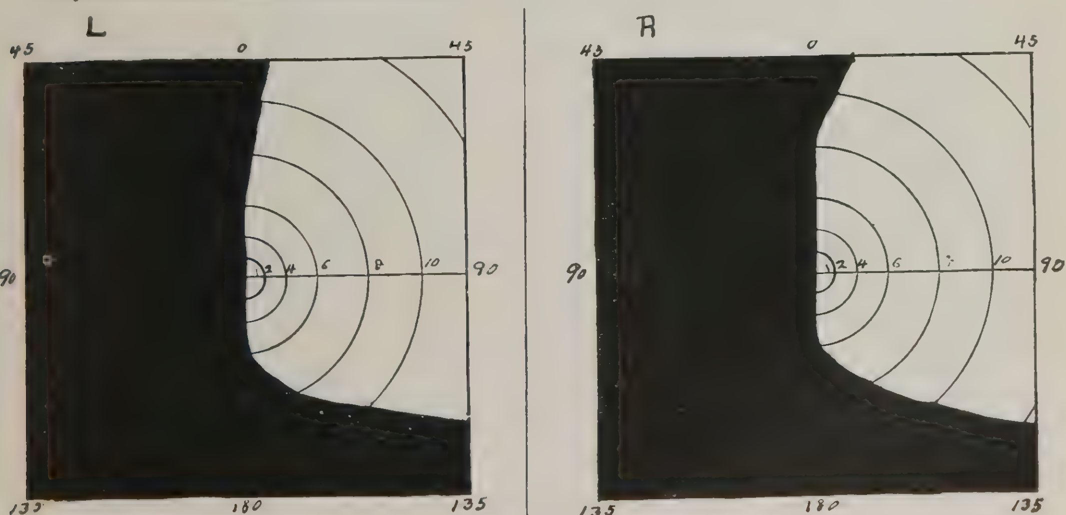
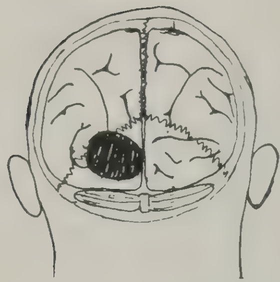
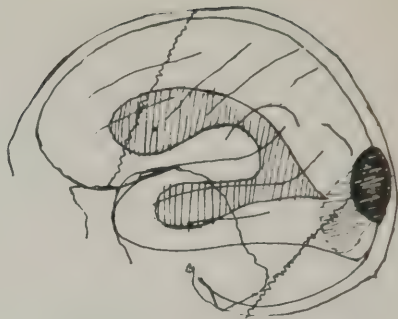


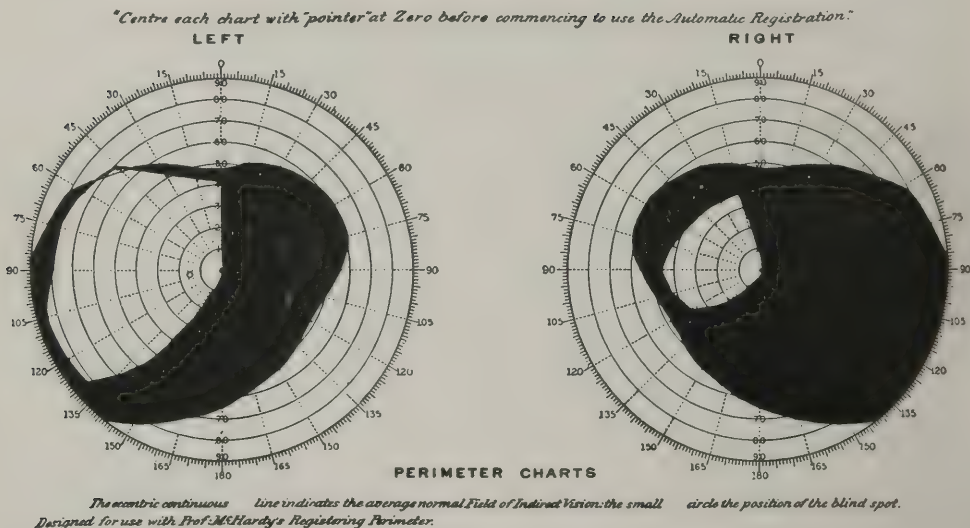
Fig. 19.



Case No. 28 L.S. Left occipital wound and defect Right hemianopsia and impairment of the left fields



Case No. 28, lateral aspect showing outlines of cyst cavity and air filled lateral ventricle.



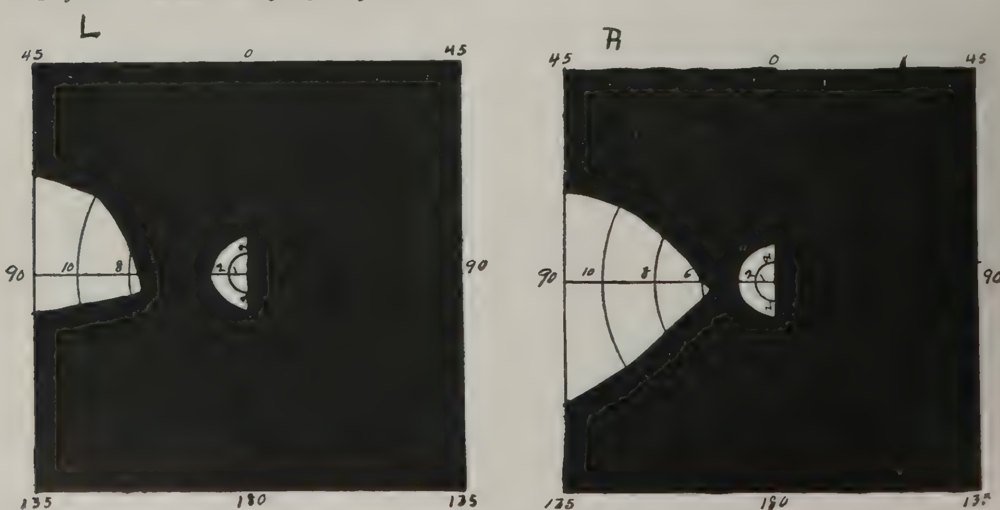
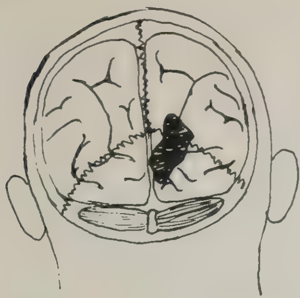


FIG. 20.



Case No. 29, B.H. Right occipito-parietal wound and defect. Complete left hemianopsia. Incomplete right hemianopsia.

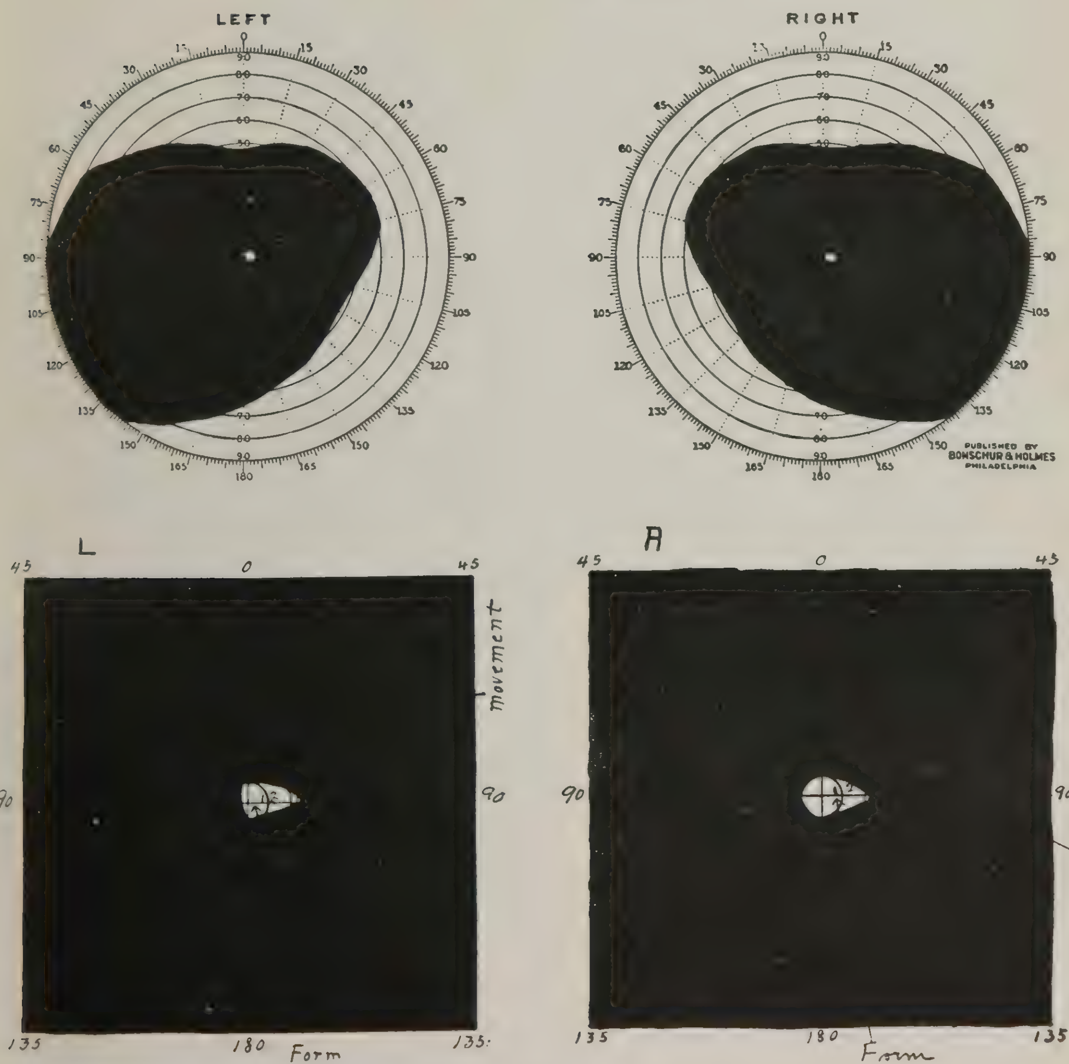


FIG. 21.

Case 30.—V. M. Wounded October 14, 1918. Transverse tangential wound just below the inion; early operation. Immediately after the injury "everything looked white." Within one week patient was able to distinguish objects. Admitted to General Hospital No. 11 in January, 1919. Pupils and fundi normal. Thin superficial opacity of left cornea. Charts of the visual fields; practically symmetrical scotomata of irregular outline, situated for the most part in the right fields, but extending to the left below the fixation point. (Fig. 22.) The macular areas are invaded to the fixation point, and central vision is reduced O. D. 20/70, O. S. 20/100. The left physiologic blind spot is abnormally large. Peripheral limits of both fields were approximately normal. Unfortunately there were no X-ray records of this case, and the fields were not charted on a screen. It is of interest, however, in correlating the scotomata with what was apparently a small cerebral lesion. From the fact that the acuity of central vision was reduced it is probable that neither occipital lobe remained entirely intact; that the major portion of the scotomata occupied the right fields, and a minor portion occupied the left fields indicates lesion of both occipital lobes, the left to a greater extent than the right. Since complete hemianopsia was not present, neither occipital lobe was extensively involved. From the character and location of the wound it

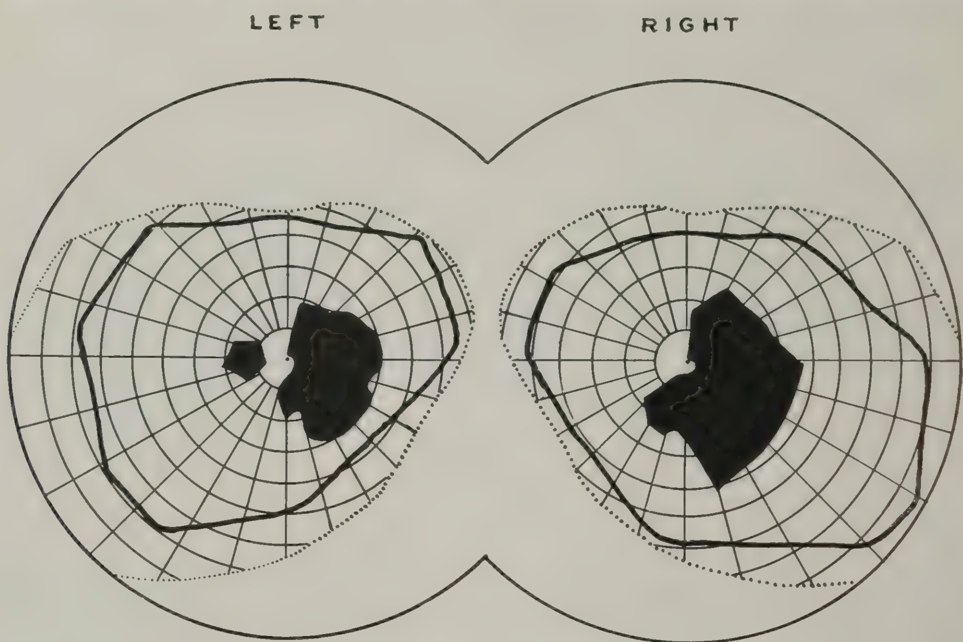


Fig. 22.—Case 30: Transverse tangential wound below inion. Partial hemianopsia.

seems certain that any injury to the cerebrum must have been limited to the immediate vicinity of the occipital poles.

Case 31.—F. E. G. Wounded July 18, 1918, in the right occipital region. Early operation; bone fragments removed. Admitted to General Hospital No. 11, November 6, 1918. Symmetrical scotomata in the left fields (Fig. 23) with normal fixation and visual acuity O. D. 20/20, O. S. 20/20.

Case 32.—T. C. Wounded October 3, 1918, left occipitoparietal region. X ray showed defect 4 by 5 cm. involving the occipital and parietal bones (Fig. 24), and a linear fracture extending across the parietal eminence from the defect. The charts of the fields of this case were lost, but it is recorded that both visual fields were defective in the lower right quadrants. The patient was right-handed, and was able to read intelligently.

From the data obtained from the observation of this series of cases attention may be called to the following points:

(1) Fixation of vision and normal visual acuity (20/20 or better) are commonly retained where lesions of the occipital lobe have caused a complete homonymous hemianopsia (Cases 20, 22, 24, 25, and 27). In no case was there

any indication that a unilateral occipital lesion caused a loss of fixation or of visual acuity, with the possible exception of case No. 23, in which vision of the left eye was 20/30 (right eye enucleated). Error of refraction was not excluded as a

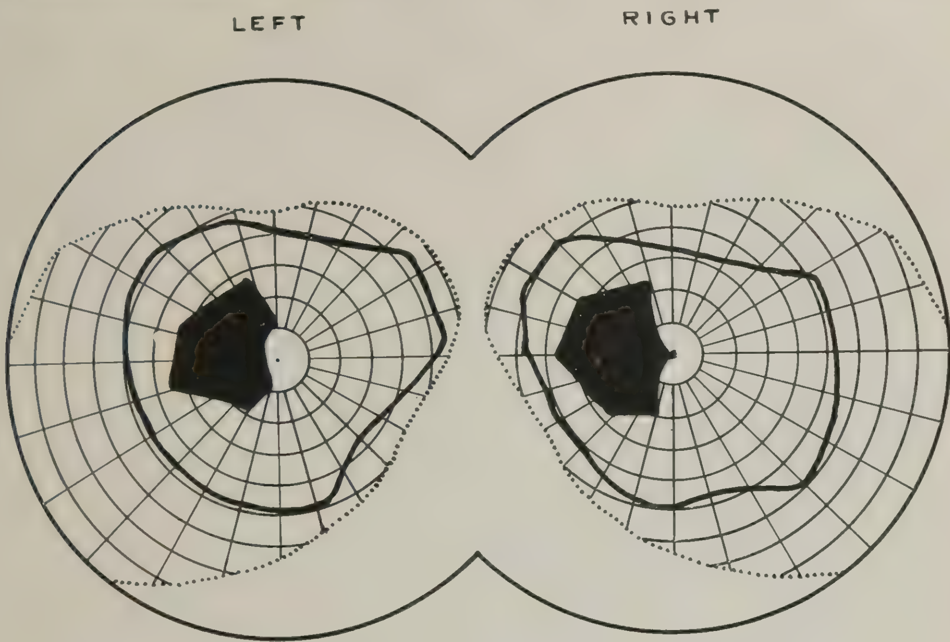


FIG. 23.—Case 31: Right occipital wound. Symmetrical scotomata in left fields

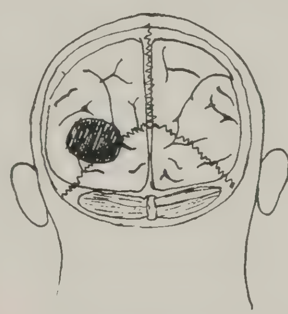
cause of imperfect vision in this case. In all of the cases in which the character of the wounds indicated that both occipital lobes were injured, visual acuity was reduced in both eyes (Cases 26, 28, 29, and 30). No disturbance of fixation was demonstrated even in these cases.

(2) The hemianopic fields commonly approached to within a fraction of one degree of the fixation point.

(3) Evidence that macular vision is represented in the apex of the occipital lobe is furnished by Case 30.

(4) Defects of the visual fields, scotomata or hemianopsias, resulting from lesions of the occipital lobes, are roughly symmetrical but not exactly superimposable.

(5) Greatly reduced visual perception in homonymous fields (incomplete hemianopsia) may exist as a permanent residual result of occipital injury (Cases 21 and 29). In such cases bright lights and large moving objects can be discerned in fields which are blind to the usual tests for form and color.



Case No. 32, T.C. Left parieto-occipital wound and defect. Homonymous lower right quadrant visual defect.

FIG. 24.

In comparing the conclusions of Holmes and Lister with those of Morax, Moreau, and others it will be noticed that there are apparent contradictions in regard to the cortical representation of the macula. Holmes and Lister defi-

nitely state that the macula has not a bilateral representation, while Morax says that it is necessary to admit of a small zone at the point of fixation, probably one degree in extent, which possesses very complex connections, since he has never found fixation affected in unilateral lesions. Visual acuity was not specifically mentioned by Holmes and Lister, but the observations of Morax and ourselves show that central vision is commonly normal in cases of hemianopsia from occipital lesions, even where the blind areas extend to the fixation point. Morax makes a distinction between the "fixation point" and other parts of the macula, and uses the designations "area of precision" and "periphery of the macular area," from which it is clear that he conceives the macula as an area of high visual acuity, and the fixation point as its center. If this conception be accepted, the charts of various observers indicate that half of the macular area is included in the hemianopic field; the median vertical boundary of the hemianopic field bisects the macula as well as the peripheral portions of the field. From this it may be concluded that each macular "area" as a whole has bilateral connections in the cortex, the right half of each macula being represented in the right occipital lobe, and the left half in the left lobe.

Concerning the question of an overlapping of the retinal areas in relation, respectively, with the right and left occipital lobes, certain evidence and analogies may be considered:

(1) Fixation was never lost in unilateral occipital lesions. (2) In the cases most carefully charted it was constantly observed that vision was retained a fraction of a degree to the blind side of the fixation point. If the fixation point is a fixed point, a small overlap of innervation is indicated. (3) The well-known overlapping of the sensory end-organs of the skin in adjoining peripheral nerve areas, and spinal segment areas, and especially the sensory overlap along the entire midline of the body, each half of which is in relation with the opposite cerebral hemisphere, may be taken for analogies for an overlap of the retinal innervation. It appears, therefore, that a very small overlapping innervation of the retina exists along the entire line of division between its lateral halves, and that the fixation point, situated on this line, actually possesses bilateral cortical representation as do all other points along the same line. This conception is apparently consistent with all of the phenomena observed in this series of cases, and, it is believed, with those of other observers.

The results of the studies of the surgeons who studied and reported these interesting conditions may be summarized briefly as follows:

(1) Unilateral occipital lesions commonly result in homonymous hemianopsia, the blind field of each eye being limited by an approximately vertical line passing close to the fixation point.

(2) Unilateral occipital lesions do not result in a loss of fixation nor a reduction of acuity of central vision of either eye.

(3) Central vision is represented in the apices of the occipital lobes.

(4) Unilateral lesions at a distance from the occipital pole may result in approximately symmetrical paracentral scotomata.

(5) Visual defects caused by lesions of the occipital lobes are approximately symmetrical but not exactly superimposable.

(6) Our conception of the macula is a central area of high visual acuity, not sharply circumscribed, extending a short distance in all directions from the fixation point which probably represents less than one degree in the arc of the visual field.

(7) The hypothesis is suggested that a minute overlap of innervation exists along the entire vertical line separating the retinal halves. Each half of the macula is thus in relation with the corresponding occipital cortex, and the fixation point, situated on the line of division, possesses bilateral cortical connections.

CYSTICERCUS OF THE VITREOUS.

The clinical observations on which this report is based were made in the School of Opthalmology, Fort Oglethorpe, Ga.,[8] and are here included, although the subject of vitreous disease was a woman in domestic service, because of the rarity of the affection in this country and the opportunities of clinical investigation which were offered.

Case 33.—History: An unmarried woman, aged 19, born in Ireland, who had been a resident of the United States for 34 months, and whose family and personal medical history, so far as it was possible to obtain it, was unimportant, had always been a healthy girl, and, with the exception of measles at the age of 14, had had no illness. Ten months prior to the examination she had noted blurred vision of the left eye. This gradually increased and was associated with the appearance of white, cloudy masses floating in front of the eye. At the expiration of five months they ceased to be apparent, and she was no longer able to distinguish even bright light. Ocular examination (July 14, 1918): Vision of the right eye was 20/20, of the left eye nil. The palpebral fissures were equal in width, the muscle rotations normal. The right pupil responded promptly to light and in accommodation, the media were clear, the disc slightly reddened in outline, and there was a slight pulsation of the inferior retinal vein. A single cilioretinal artery was noted on the temporal side. The general vascular system was normal and the refraction slightly hyperopic.

The pupil of the left eye dilated readily, and there were no gross changes in the iris; but in the lower portion of Descemet's membrane were a number of punctate deposits and two or three small dots on the anterior capsule of the lens, indicating previous points of adhesion between it and the margin of the iris. The vitreous was moderately cloudy, and there were a few fixed vitreous opacities in the anterior portion of this body. From the upper and inner quadrant a gray reflex was visible, indicating a choroidal infiltration, or perhaps a retinal detachment. Owing to the cloudiness of the vitreous directly in advance of this area, it was not possible to discern accurately, or focus on, any retinal vessel. The region of the disc was visible through the hazy vitreous, and its position could be differentiated by its color, but no vessels were distinguishable.

Quite anterior in the central field of the vitreous and well in advance of the retina of the macular region, there was a large globular mass, light gray, with a slightly darkened center. The outline was regular and its border almost transparent. It was translucent toward the center, and it was from 6 to 7 disc diameters in width. From its lower border there protruded a tubular extension transversely wrinkled, which terminated beyond a slightly constricted neck into a head on which two bright dots, and the position of the hooklets, could be distinguished. Distinct peristaltic movements of the cyst were visible and the movements of the protruded head, neck and body were often very active. At times the head was withdrawn within the sac, very much as might be the case with the head and neck of a diminutive turtle. (Plate VIII-A.)

During a number of observations on the days following the discovery of the cysticercus, the conditions did not materially change, except that in various movements the observations could be improved. Thus, sometimes the head was situated directly downward, sometimes downward and forward, and sometimes more to the temporal side. Depending evidently on differences in the density of the vitreous opacities, the walls of the cyst, particularly those on the temporal side, were more clearly demonstrable. In short, the movements of the parasite, to use the language of Saltzmann, presented an everchanging and interesting spectacle. Naturally, the diagnosis of cysticercus of the vitreous was readily made.

General and laboratory examinations: The patient was a well-nourished, rather pale girl, who in a few months prior to her examination had lost weight, and quite recently her appetite had been impaired and she had suffered somewhat from nausea. But the general examinations of the heart, lungs, and abdominal viscera were negative, with the exception that one roentgenogram indicated a slight thickening in the region of the gall-bladder. On repetition, however, of this examination, the roentgenologist was unprepared to say that this appearance was of pathologic significance. The urine showed no pathologic content; the blood count was, red blood corpuscles, 3,450,000; white blood cells, 5,000; the Wassermann test of the blood was negative. An examination of the stools revealed the presence of ova, but no segments of the worm. It was supposed

that these ova were those of *Tænia saginata*, but, as is well known, sometimes the eggs of this tapeworm and those of *Tænia solium* so closely resemble each other that they can not be distinguished microscopically, and the ophthalmoscopic appearance of the hooklets leaves no doubt that the ocular intruder was *Cysticercus cellulosæ*.

Operation: After keeping the patient under observation for two weeks, during which there was a manifest increase in the vitreous density and descemetitis, it was determined to operate, after the patient had been fully informed as to the chances of operative success and failure and also fully informed that if the parasite was not removed the eye was doomed to a destructive inflammation. The following operation was performed: An incision was made in the conjunctiva with scissors between the external and inferior rectus muscle, beyond the ciliary body and parallel with the corneal margin. Next, the sclera was incised longitudinally with a Graefe knife, the incision being 1 cm. in length, passing through the sclera, choroid and retina. At once fluid vitreous exuded. Guided by means of an electric ophthalmoscope, forceps were introduced into the opening and the cyst grasped and its removal attempted. This, however, was impossible owing to the fact that it promptly ruptured, and further efforts were not made. The wound was closed with conjunctival sutures and a dry dressing applied.

For three days there was no reaction, when pain developed in the eye, lasting for about an hour. A small point of adhesion to the iris and the lens in the upper and outer quadrant was discovered, but there was no ciliary injection. The lens, however, was quite milky in appearance. Convalescence proceeded uneventfully, and four days after operation the patient was discharged, the eye being free from irritation but the lens cataractous. Twenty-eight days after operation the eye suddenly became very painful, the conjunctiva was intensely congested and there was marked ciliary injection, the iris being dull, dark, and slightly greenish in hue. The patient was advised to permit the enucleation of the eye, to which operation she consented. Following this operation there were no complications, and at the expiration of a proper period an artificial eye was adjusted, and it was noted that the patient's general condition began very rapidly to improve. Practically six weeks after the enucleation of the eye the patient reported that a hemorrhage had occurred from the socket. She was immediately examined, and a clot of blood found at the apex of the orbit. This hemorrhage was coincident with a menstrual molimen. About one ounce of blood was lost, but no further hemorrhage occurred. She gave the history that on one previous occasion menstruation had been associated with epistaxis. Since this date there has been no report of any complication.

Cysticercus of the vitreous has not been noted in native Americans; and only four cases have been reported in this country.

CONGENITAL MULTILOCULAR CYSTS IN RELATION WITH THE RETINA.

An example of this unusual lesion, also observed in the School of Ophthalmology at Fort Oglethorpe, Ga., is the following:[8]

Case 34.—A soldier of the Medical Department, aged 22, was referred to the ophthalmic service because of defective vision of the left eye. There was no history of injury and no evidence of constitutional disease. This defective vision had existed from childhood and at the time of examination vision equaled light perception. The media were clear, the disc was pale and sharply outlined, and to its outer side there was a small crescent of choroidal disturbance. The arteries were small and straight, the veins normal in size, color, and outline. In the macular region a large white atrophic spot, slightly greater in diameter than the disc area, was visible. Protruding from the upper half of this area there was a large cyst formation in shape somewhat resembling an observation balloon. Its summit was best studied with +4.50 D. On the surface was a number of small vessels. It was transparent, and it covered about three-fourths of the atrophic macular area. Extending from the lower temporal edge of this cyst for a distance of about 3 disc diameters there was a narrow transparent tube carrying two atrophic vessels. This tube resembled in appearance and size a manifest canal of Cloquet. The canal terminated in a wide-spreading cyst mass, which was less transparent than the one in the macular area, and fully four times as large. It possessed the shape of a rounded cone, with the base gradually losing itself in the peripheral part of the temporal quadrant of the retina. On its superior surface there were numerous small cysts, or vesicles, some of which were confluent. The surface of the mass was covered with vessels, which were for the most part atrophic. In the lower quadrant of the field the retina was elevated 2 diopters. (Plate VIII-B.) The entire middle and lower field of the fundus was occupied by retinal pigment deposits, unassociated with any atrophic spots, with the exception of one to the nasal side of the inferior temporal artery, just below the disc, and two less pronounced ones still farther below. The vision of the right eye was 20/20 and the eye ground was entirely normal.

A. CYSTICERCUS OF VITREOUS.

B. CONGENITAL MULTILOCULAR CYSTS IN RELATION WITH THE RETINA AND ASSOCIATED WITH QUIESCENT PIGMENTARY RETINOCHOROIDITIS.

As explanation of the retinal lesions, the ophthalmologists who reported this case have suggested that the balloonlike cyst, from which a cord carrying two vessels passed to the temporal portions of the retina, terminating in the large multilocular cystic area, may be an eccentric vestigial hyaloid vessel with a bulbous expansion at its origin, bent over and twisted away from an approach to the posterior surface of the lens, to be fastened as is portrayed in the illustration. Choroiditis, such as was observed, probably congenital, has been reported in a number of examples of persistent hyaloid artery and its anomalies.

The whole process may also be explained by assuming that in intrauterine life there developed some type of hemorrhagic retinochoroiditis, and that cystic changes occurred in the secondary exudative processes. There seems no doubt that the balloon-shaped mass was a cyst, and the large area in the temporal periphery of the retina almost certainly represented a mass of exudation which elevated the retina (it may have started in the choroid), and in this elevated retina multilocular cysts developed.

ANTERIOR LENTICONUS.

A very rare lenticular anomaly was observed in United States Army General Hospital No. 14, Fort Oglethorpe, Ga., and had formed the subject of a brief special report.[8]

CASE 35.—A recruit, aged 20, was referred by the camp infirmary for examination because of defective vision which had existed from infancy. It was possible to see him only once. Vision right eye was 8/200; left eye 10/200. It was not possible in the brief time at the disposal of the examiners to ascertain whether any spheric or cylindric combination could improve vision. Each lens presented a pronounced anterior cone, which could readily be seen by ordinary daylight, looking through the anterior chamber, especially from the side and also when the pupils were dilated. During this dilatation it was noted that the lenses were small and slightly hazy, except in the region of the zonula. Fundus examination by the indirect method detected no abnormality. The tip of each cone almost touched the posterior layer of cornea. (Fig. 25.)

FIG. 25.—Anterior lenticonus.

So far as is known, this is the only example of this lesion which has been observed in the medical service of the Army, and is one of the few which have been reported in this country.

CONGENITAL ANOMALIES.

A number of congenital anomalies were observed and are listed in the statistical tables, for example, albinism (5 cases), coloboma of the iris (65 cases), persistent pupillary membrane (11 cases), polycoria (8 cases), coloboma of the choroid (6 cases), coloboma of the optic disc (6 cases), coloboma of the lens (1 case), persistent hyaloid artery (10 cases). These figures, naturally, do not represent all of the congenital anomalies which existed among the large number of troops examined, but they do represent, in all probability, all of the soldiers thus affected who reported at the various eye services, whose lesions were detected.

More than 200,000 troops were examined at Camp Travis, Tex., before the armistice was signed. Among the men referred to the special medical examining board as eye cases 28 had a congenital condition of the fundus or of the bulbus, which caused a reduction of vision.[9] The most important

congenital lesions noted include coloboma of the choroid, opaque nerve fibers, congenital pigmentation, and congenital varicosity of the retinal veins, coloboma of the iris, and several cases classified as congenital guttate choroiditis. One case of coloboma of the lens was observed in this group.

A very rare congenital anomaly of the choroid was observed in base hospital, Camp Logan, Tex., namely, choroideremia.[10] Investigation of this patient, a well-developed soldier 25 years of age, revealed normal direct vision, moderate contraction of the field of vision, and a striking abnormality in that the entire choroid of each eye was absent, with the exception of a small area in the region of the macula. The patient was night-blind.

BLEPHAROPLASTY AND OCULAR PROSTHESIS.

The ordinary blepharoplastic procedures were required with comparative infrequency in the various hospitals in this country prior to the arrival of men who had been wounded in France. After that time, operations of this character frequently became necessary, and for the most part were performed in those hospitals which had been designated as eye centers, especially in General Hospital No. 2, Fort McHenry; General Hospital No. 11, Cape May; Walter Reed General Hospital; General Hospital No. 14, Fort Oglethorpe; General Hospital No. 6, Fort McPherson.

In the statistical tables the following operations pertaining to this class of work are listed: Ectropion operations 35, orbital operations 3, plastic operations on the orbit 16, contracted sockets 28.[a]

As examples of this character of the work, which included correction of distorted lids, orbital implantations, etc., reports from two general hospitals (No. 11, Cape May, and No. 2, Fort McHenry) have been selected, and all the illustrations appearing in this part were received from these two hospitals.[b]

PLASTIC REPAIR OF THE EYELIDS BY PEDUNCULATED SKIN GRAFTS.

The following cases were selected from a report prepared by the chief of the eye service, General Hospital No. 11, Cape May.[11 c]

CASE 36.—Absence of lower lid; exposure of conjunctiva; absence of eyeball. S. H., aged 30, injured October 9, 1918, was operated on April 17, 1919. The eyeball and the entire lower lid had been lost following injury by machine-gun bullet. The mucous membrane was drawn over the outside surface by the resultant scars and allowed the secretions to drain over the cheek, thus preventing the retention of a prosthesis. A pedunculated temporal graft was used, the temporal artery in the base being employed as the blood supply. Following the extirpation of the lacrymal sac, the edges of the lower lid and conjunctiva were freed from the scar, and the edges were dressed up to determine the size and shape of the graft required. A temporal graft was selected, marked out with the point of a knife, dissected and swung into place. It was sutured with interrupted silk sutures, or mattress sutures, with a continuous overcast suture to approximate the edges. The denuded area from which the graft had been taken was covered by undermining the surrounding skin well back, drawing the edges together, and suturing with silk, horsehair, and silkworm gut. This pedunculated flap supplied the tissue for the outer surface of the lid, while the inner surface was obtained by an Esser tunnel. (Figs. 26, 27, 28, 29.)[d]

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[a] This numerical tabulation fails to include many operations of this character which were performed after April 1, 1919, when the statistical material then available was compiled, as well as those which were necessary in association with the larger procedures of maxillofacial surgery, which are elsewhere recorded. Moreover, the tabulation is incomplete in that a number of operations were reported too late for inclusion in the tables, although they took place prior to April 1, 1919.

[b] Only a few of the many photographs and drawings which were sent have been utilized to illustrate the principal procedures employed; the remainder are on file in the Surgeon General's Office.

[c] The members of the staff who participated in the blepharoplastic surgery service were: Capt. George H. Cross, Maj. Meyer Wiener (for a time chief of service), Lieut. Wm. A. Kreiger, Lieut. W. S. Reese, and Lieut. H. W. Scarlett. The author is indebted to Captain Cross for many of the photographs and this arrangement.

[d] The final photograph of this series of operations was taken before sufficient time had elapsed to dissipate the swelling of the tissues by massage, which, as emphasized in the report, was utilized with satisfying result.

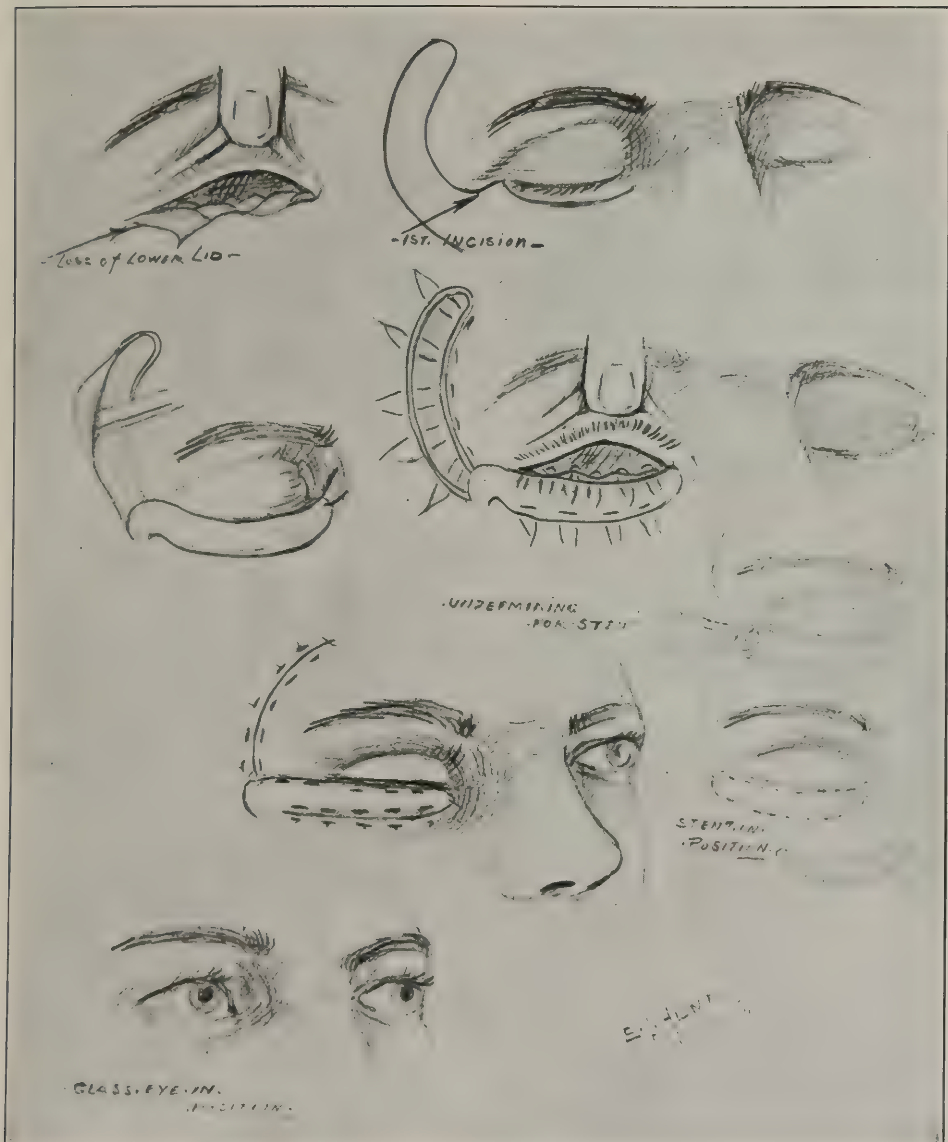


FIG. 26.—Case 36: Schematic drawing showing restoration of lower conjunctival cul-de-sac by a pedunculated flap graft following an Esser inlay.

FIG. 27.—Case 36: Absence of lower lid with discharge of tears and exposure of conjunctiva.

FIG. 28.—Case 36: Pedunculated graft sutured in place by mattress suture and interrupted sutures of silk.

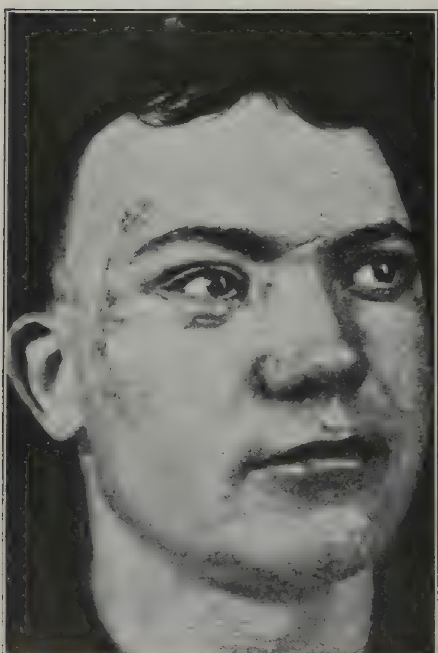


FIG. 29.—Case 36: Immediate result following Esser inlay, showing tissues in swollen condition before toning down by massage; artificial eye held in new lower cul-de-sac by a new lower lid.

CASE 37.—Absence of eyeball; loss of inner two-thirds of eyelid; injury to bridge of nose. H. C. K., aged 23, injured November 6, 1918, in France. There was loss of the inner portion of the eyelid and destruction of the eyeball, which had been removed. A new lid was formed by means of a cheek-pedunculated graft. Although, owing to the secretion from the lacrymal sac, a minor temporary infection occurred, the graft was not lost, and the final result was most satisfactory.

The operator in his report commends continuous use of hot compresses steeped in normal salt solution to combat infection, and advocates the need of extirpation of the lacrymal sac prior to the performance of such an operation, and the employment of heavy silkworm gut sutures to coapt the edges of the area from which the graft is removed. (Figs. 30, 31, 32, 33.)

CASE 38.—Loss of right eye; contracted socket and loss of lower lid. H. C. S., aged 28, injured July 18, 1918, was operated on April 1, 1919. In addition to the loss of the middle of the lower lid of the right eye, this soldier also had a contracted socket and loss of bony tissue, as shown by a marked depression beneath the socket. The defects followed injury by a machine-gun bullet, which after destroying this eye passed down through the hard palate and mouth and lodged in the left side of the neck just under the skin; it was removed by means of the fingers without operation.

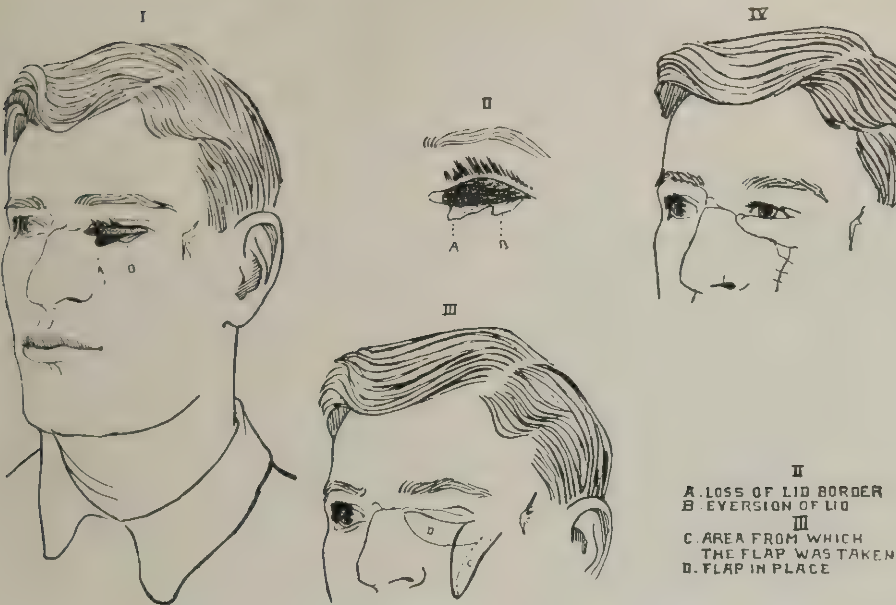


FIG. 30.—Case 37: Schematic drawing of restoration of lower lid by a pedunculated cheek graft.

FIG. 31.—Case 37: Absence of left eye, which was destroyed by a fragment of high-explosive shell which entered the temple (at sight of scar), destroyed the eye and the inner two-thirds of lower lid, and injured the bridge of the nose.

FIG. 32.—Case 37: Flap sutured in place, swelling indicating infection; cheek sutures of silkworm gut.

Operation: The procedure was similar to that employed in Case 36, in that it was also preliminary to an Esser tunnel to form a new lower cul-de-sac. The cheek was selected in order to obtain a graft thick enough to build up the depression over the antrum. On May 1, one month later, an Esser tunnel operation was performed. The lower incision of the graft would have been opened and a layer of fat turned from under the graft down under the skin of the face to fill up depression had the patient remained long enough for this procedure. (Figs. 34, 35, 36, 37.)

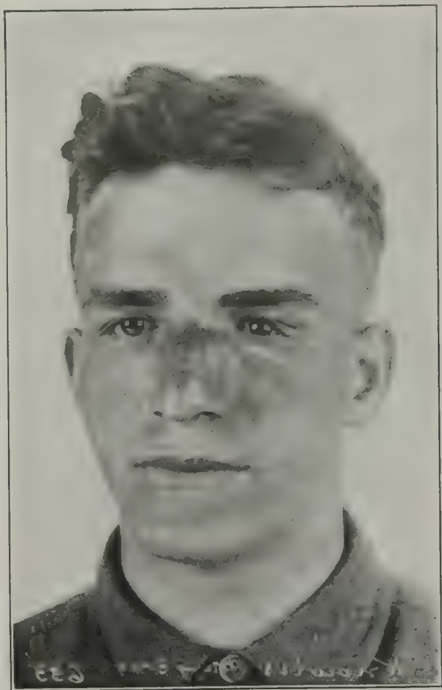
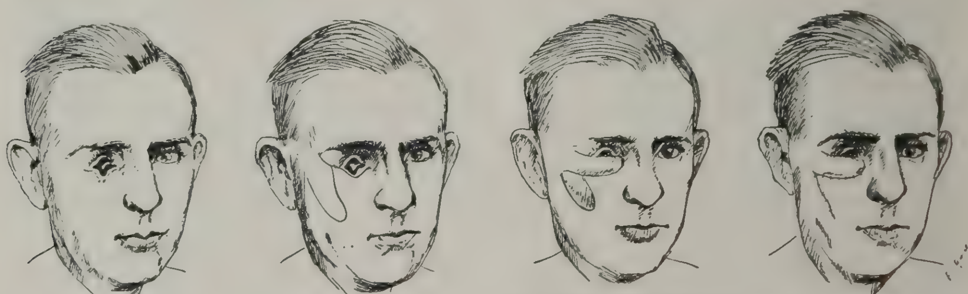


Fig. 33.—Case 37: Final result at time of patient's discharge; no bad results from the infection; artificial eye in place.

Case 39.—Sinus at base of bridge of nose; distortion of the upper lid; and inferior ectropion. M. G. S., injured July 15, 1918, was operated on January 22, 1919. The defect of the eyelids and nose was caused by a piece of shrapnel or high-explosive shell, which destroyed the tissues and bony covering of the anterior ethmoid cells. Discharge of secretions from the nose through the sinus in the ethmoid region, marked ectropion of the lower lid, distortion of the upper lid due to scar contraction and a constaut overflow of tears were evident. The eyeball had escaped injury.

Operation: First the scar was dissected out and the tissue freed from its bony attachment. This allowed the lids to be restored to their normal position. Next a plug of sterile gauze, tied to a strand of heavy silk, was pulled in through the wound until it blocked the bony opening. This prevented the secretions from the nose gaining access to the under surface of the flap. The opening in the bone was covered with a thin sheet of paraffin wax, after which a rather wide graft was swung from the forehead, so that in addition to covering the sinus, it would push up the border of the lower lid, correcting the ectropion, and at the same time relieving the tension on the upper lid. The wounds healed by first intention, after which the plug was removed. No attempt was made to readjust the base of the flap. (Figs. 38, 39, 40.)



Before operation

Line indicates incision for flap

Flap in place which pushes up mucous membrane to deepen socket and form new lower lid

Flap in place showing sutures

Fig. 34.—Case 38: Schematic drawing of pedunculated cheek graft to restore lower lid, preliminary to an Esser tunnel to form new lower cul-de-sac.

As the type of each "repair," or plastic operation, must be planned according to conditions, which vary from those requiring only separation of bands of adhesion in the orbit to those which need complete restoration of the socket

and of the eyelids, the following briefly described operations are appended in illustration of the work which was done in United States General Hospital No. 11, Cape May.

CASE 40.—L. B., Pvt., Co. D, 18th Inf., aged 28, injured October 6, 1918, in Argonne Forest; three weeks later the right eye was removed. Operated January 2, 1919, Blepharoplasty right upper lid to restore continuity of lid border, separation of bands in socket to better permit the retention of an artificial eye. (Figs. 41, 42.)

CASE 41.—G. T., Pvt., Co. E, 116th Inf., aged 25, injured October 28, 1918, shrapnel. A large scar in the temporal region, following an osteomyelitis from a compound, comminuted fracture of the malar bone, which retracted and pulled the outer canthus and both eyelids to such an extent that it was impossible to open the eye. A pedicle graft from the temple was swung in to cover scar area and the denuded area, after the eyelids were restored to their normal position. The deep scar in the cheek, the result of a healed sinus from the antrum, was also corrected. (Figs. 43, 44, 45, 46.)

FIG. 35.—Case 38: Loss of right eye, contracted socket and loss of lower lid; injury by machine-gun bullet, which passed through right eye, ethmoid, maxillary sinus, and hard palate, and out the left side of the neck.

FIG. 36.—Case 38: Pedunculated flap from the cheek sutured in place (first dressing); cheek sutures of silkworm gut, flap sutures of black silk.

FIG. 37.—Case 38: Case not completed, artificial eye in place following Esser inlay; scar on neck shows exit of machine-gun bullet, which entered through the right eye. Layer of fat to be shifted from under flap to fill depression over antrum was the next contemplated procedure.

CASE 42.—R. W. D., Pvt. Co., K, 4th Inf., aged 20, injured July 24, 1918, at Chateau Thierry, by machine-gun bullet, which destroyed the left eye and the upper, outer bony rim of the orbit. The eye was removed later at a field hospital. The contraction of the upper lid and the loss of lid surface was sufficient to prevent the retention of an artificial eye. After dissecting out scar on the lid and freeing it from the bony rim, the lid was sewed to a piece of adhesive plaster on the cheek in order to provide a firm base upon which was transplanted a large epidermal graft taken from the arm. This was treated by the open method. (Figs. 47, 48, 49.)

CASE 43.—E. R. W., 1st Lieut., Co. E, 315th Engineers, aged 25, injured September 26, 1918, near St. Mihiel, by machine-gun bullets, one of which destroyed the right eye; another cut a furrow through the temple, which caused the right side of the face to slump. In this case, following the excision of the scar and the removal of the lacrymal sac, it was necessary to pull up the cheek and fasten with deep tension sutures, at the same time reconstructing the outer half of the lower lid. Two operations were necessary. (Figs. 50, 51.)

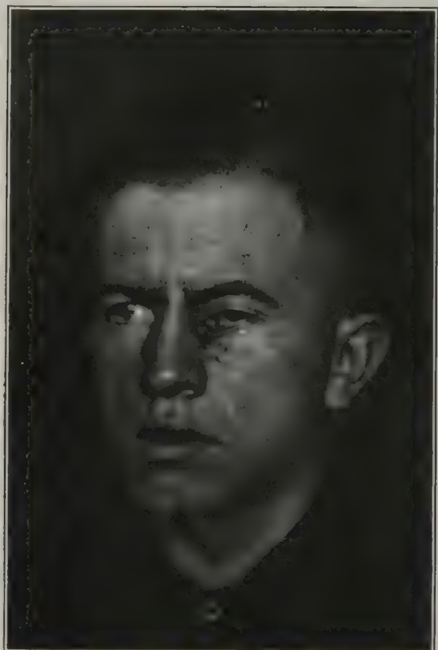


FIG. 38.—Case 39: Sinus at the base of the bridge of the nose, ectropion of lower lid, distortion of upper lid by scar tissue, following injury by a fragment of shrapnel or high-explosive shell. Secretions escaped through sinus when blowing the nose.

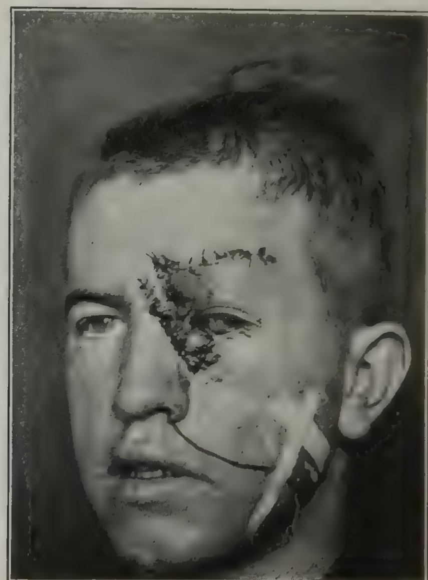


FIG. 39.—Case 39: Pedunculated forehead graft sutured in place, covering sinus and relieving distortion of upper lid and ectropion of lower lid. Black silk cord is fastened to gauze plug in ethmoid defect. Photograph taken at first dressing.

CASE 44.—J. S., Sgt., Co. G, 26th Inf., aged 32, injured July 19, 1918, at Soissons, by machine-gun bullet. A deep wound of the cheek in contracting produced a marked displacement of the outer canthus of the left eye, with ectropion of the lower lid and contracture of the upper lid. A large stellate scar in the cheek was removed. The prominent ectropion was corrected by a pedicle graft taken from the left temple. A constriction in the flap which threatened the life of the tip was relieved by pulling forward the temporal region with strips of adhesive plaster. This case illustrates the result of too much hurry in the second operation, as further contraction of the facial scar increased the ectropion, which was corrected by a small Gillies outlay. (Figs. 52, 53, 54, 55.)

CASE 45.—J. B., Pvt., Co. A, 119th Inf., aged 26, injured October 18, 1918, at St. Quentin, by fragment of high-explosive shell. Several operations were performed on this patient, a piece of shell was removed, a pedicle graft was swung from the forehead following the removal of the scar there, to correct the defect in the upper lid, a pedunculated graft was swung in from the right temple to supply tissue for the new lower lid, and lastly, an Esser tunnel provided the necessary epithelial lining for the lower cul-de-sac. (Figs. 56, 57, 58, 59.)

FIG. 40.—Case 39: Final result, showing cosmetic result obtained. No attempt was made to readjust base of the flap.

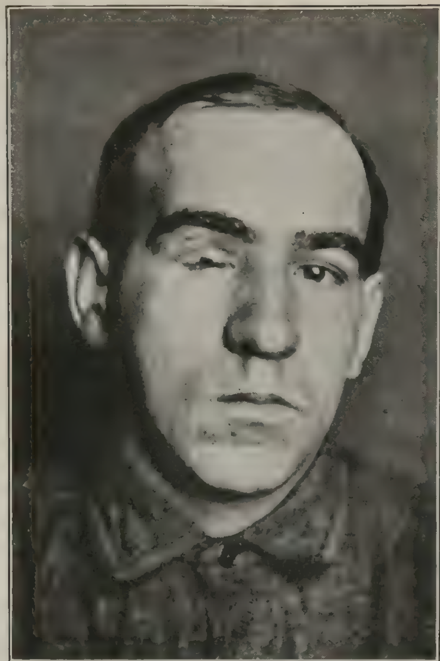


FIG. 41.—Case 40: Gunshot wound destroying right eye and lacerating upper and lower eyelids. Adhesions prevented wearing of artificial eye.

FIG. 42.—Case 40: Condition after blepharoplasty and socket repair.

FIG. 43.—Case 41: Gunshot wound, shrapnel, causing a compound comminuted fracture of left malar. Osteomyelitis caused the contracted scar and distortion of eyelids. Scar on cheek from a discharging sinus, left antrum.

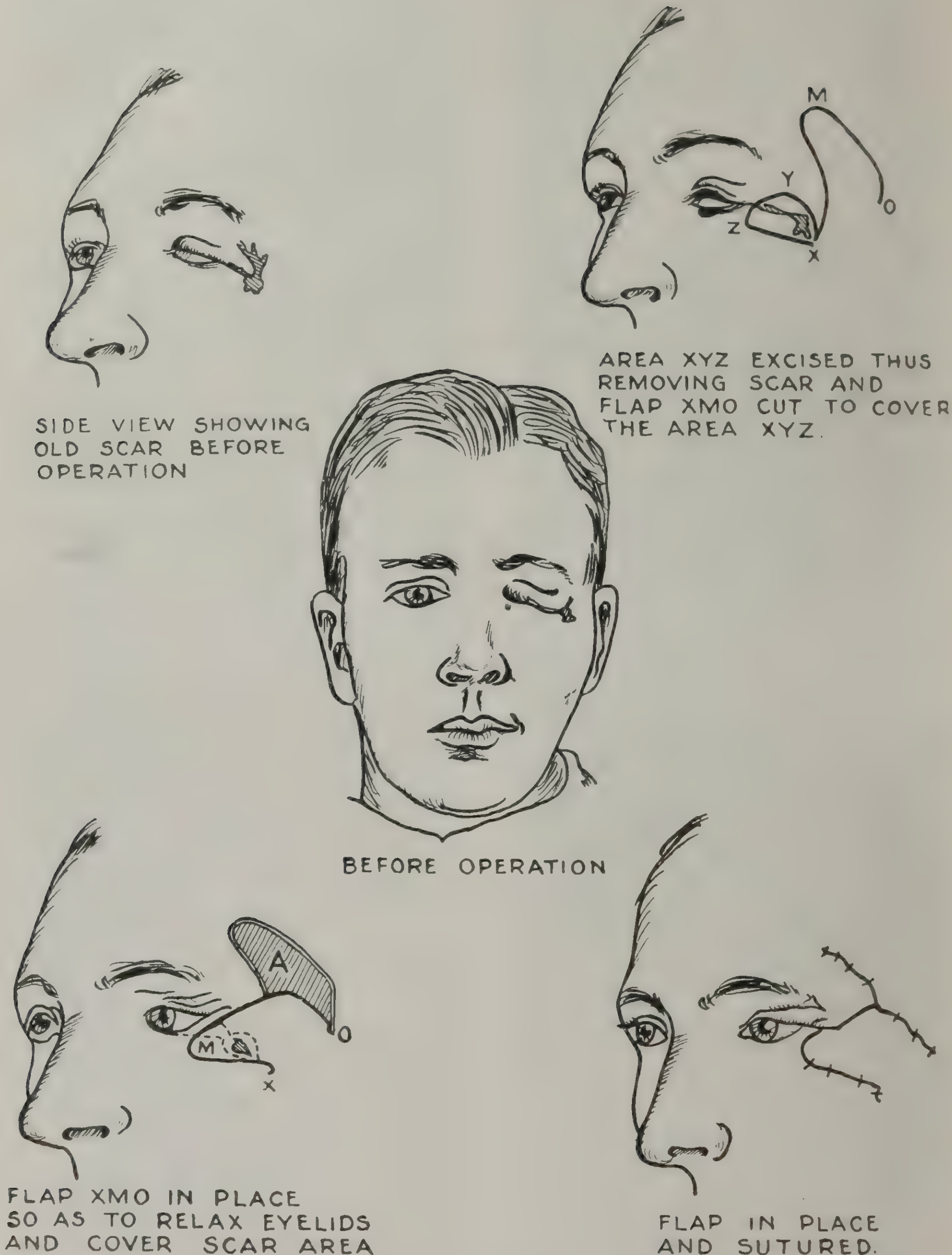


Fig. 44.—Case 41: Schematic drawing of pedunculated temporal graft to cover scar area and correct distortion of eyelids.

FIG. 45.—Case 41: Appearance of graft upon removal of sutures.

FIG. 46.—Case 41: Final result of plastic repair. Vision of left eye 20/30.

FIG. 47.—Case 42: Gunshot wound, machine-gun bullet, destroying eyeball and outer bony rim of orbit. Upper lid contracted by deep cicatrix.

FIG. 48.—Case 42: Lid freed from bone, lower border sewed down to adhesive plaster. Thiersch graft covering denuded upper lid.

FIG. 49.—Case 42: Artificial eye in place, upper lid freed from scar.

FIG. 50.—Case 43: Gunshot wound; machine-gun bullet destroyed right eye and tissue of right temporal region, causing slumping of face.

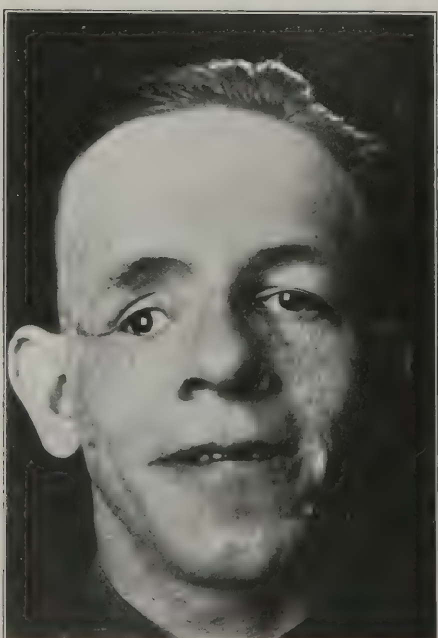


FIG. 51.—Case 43: Result of pull-up operation of face and blepharoplasty on lower lid; artificial eye in place.

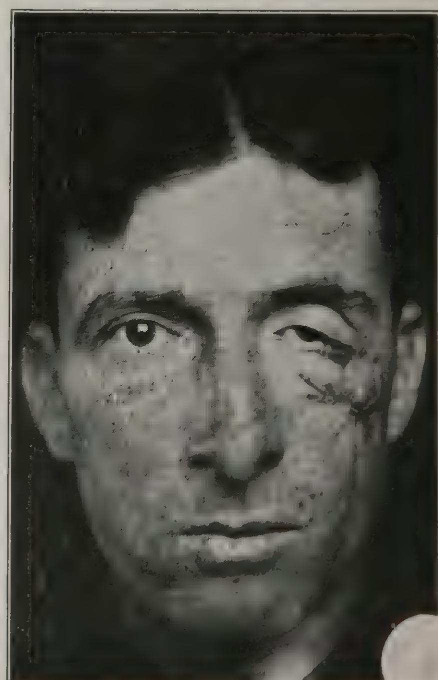


FIG. 52.—Case 44: Gunshot wound, machine-gun bullet: resultant scar contracted and distorted both eyelids and corner of mouth.

FIG. 53.—Case 44: Condition after plastic repair of face, showing marked ectropion and distortion of outer canthus.

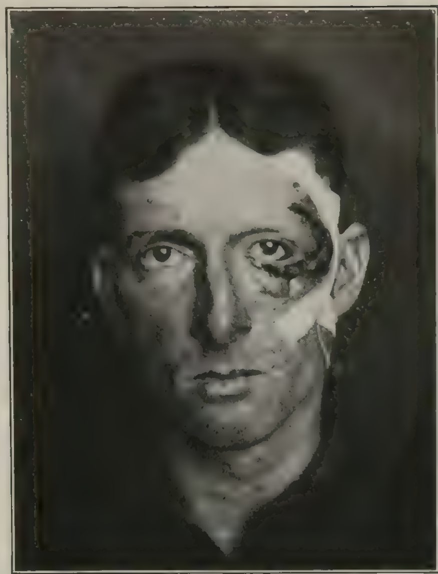


FIG. 54.—Case 44: Pedunculated temporal graft in place; adhesive plaster to pull ear forward and relieve constriction of a portion of the flap.

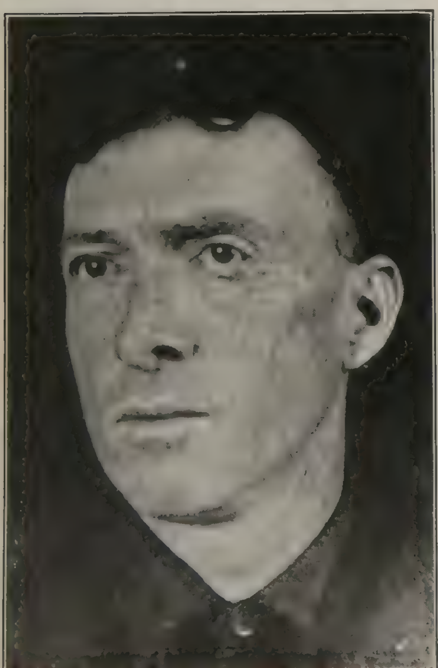


FIG. 55.—Case 44: Second operation was attempted too soon after first; ectropion corrected by "Gillies outlay." Stellate rupture of choroid. Vision 1/200.

FIG. 56.—Case 45: Gunshot wound, high-explosive shell, destroying right eye and lower lid, with laceration of upper lid.

CASE 46.—C. C. M., Capt., 351st Inf., aged 24, injured September 12, 1918, St. Mihiel, by fragment of high-explosive shell, which destroyed the left eye and wounded the left arm, necessitating removal of the eye and amputation of the arm at the shoulder. A portion of the lid margin was contracted in a mass of tissue which, when released, lessened the area to be bridged over. The lid was denuded and the free margin sewed to adhesive on the cheek. This provided support for the Thiersch graft, which was taken from the arm. He was able later to retain an artificial eye after a Thiersch graft was inserted in the upper conjunctival cul-de-sac to deepen it. (Figs. 60 61, 62, 63.)

CASE 47.—L. P. McE., Pvt., Co. K, 28th Inf., aged 20, injured May 28, 1918, at Cantigny, by a machine-gun bullet. This case required four operations before completion. The first operation was the removal of the broad scar extending from the inner canthus of the right eye outward and downward across the right cheek, which had produced a marked slumping of the face. Secondly,

FIG. 57.—Case 45: Pedunculated temporal graft sutured in place, showing mattress sutures, also triangular flap to restore upper lid.

FIG. 58.—Case 45: After healing; now ready for "Esser tunnel" to form new lower cul-de-sac.

a pedunculated graft was swung from the right temple to provide lower lid tissue. Thirdly, an Esser tunnel graft provided a lining for the new lower cul-de-sac, while the fourth was merely a blepharoplasty to improve the outer canthus. (Figs. 64, 65, 66, 67, 68.)

CASE 48.—T. B. H., 1st Lieut., Aero Squadron, aged 31, injured December 24, 1918, aeroplane accident, gasoline tank exploded, burning face. The defect in this case was a surface one and new skin was transplanted by Gillies modification of the Esser inlay. The contraction of the epithelium of the lids was such the man could not close his eyes, both upper eyelids everted. Unfortunately this case was uncompleted when the hospital was closed and he was transferred. (Figs. 69, 70, 71, 72.)

CASE 49.—J. D. C., aged 26, injured July 16, 1918. The right eye and the outer half of the lower eyelid were destroyed, the conjunctiva being retracted on the cheek by a scar at the outer canthus, which distorted both lids. The contraction of the lids and the repair of the lost lid border was effected by a temporal pedunculated graft which healed through the scar erea, this permitting the retention of an artificial eye. (Fig. 73.)

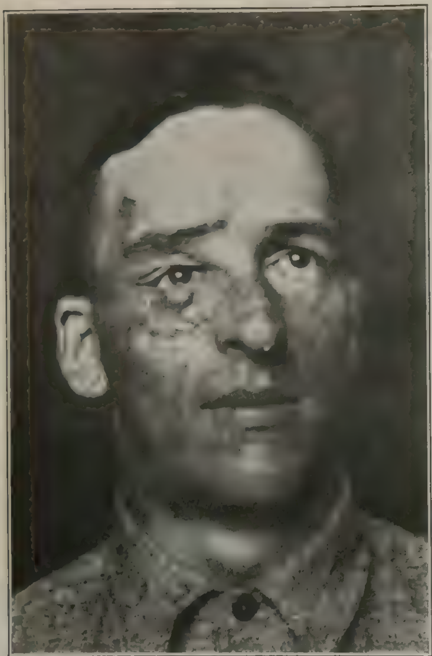


FIG. 59.—Case 45: Immediate result after "Esser tunnel." Artificial eye in place. Scars will smooth down.

FIG. 60.—Case 46: Gunshot wound; high-explosive shell destroyed the left eye and about three-fourths of upper lid border and half of lid tissue, as well as tarsal cartilage.

FIG. 61.—Case 46: Upper lid border sutured to adhesive plaster on cheek; epidermal graft from arm in situ.

FIG. 62.—Case 46: Open or dry method of dressing—a roll of gauze around the orbit and covered with perforated rubber mesh.

The photographic illustrations of end results of the various procedures described in the above series of cases were taken before sufficient time had elapsed to improve the cosmetic results by means of massage; the actual final result was far better than the pictures indicate.

An active service in plastic surgery about the eyes was conducted in General Hospital No. 2, Fort McHenry.[a] The photographs and case records which follow, and which illustrate the character of the work, were selected from a large number which were submitted.[b] [12]

CASE 50.—Coloboma of left lower lid. S. L., Pvt., Co. K, 325th Inf. Gunshot wound lower left lid. Operation February 11, 1919, blepharoplasty. Operation February 26, 1919, suture. Operation April 17, 1919, plastic. Operation June 4, 1919, extirpation of left lacrymal gland to control epiphora.

FIG. 63.—Case 46: Showing lid border repaired and artificial eye retained in socket.

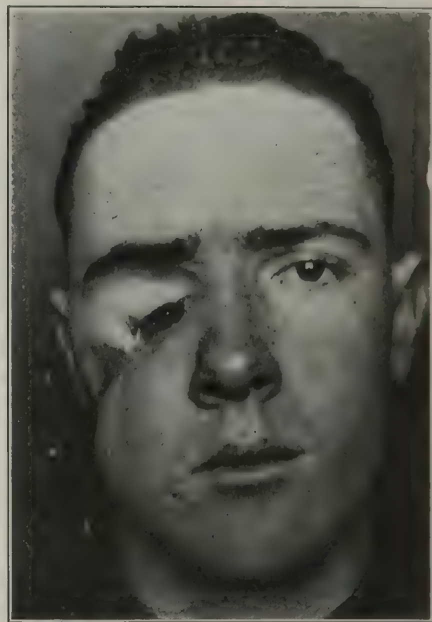


FIG. 64.—Case 47: Gunshot wound; machine-gun bullet destroyed right eye, lower lid, malar region, and caused a slumping of the cheek and a displacement of the upper lid and socket.

The illustrations indicate the series of operations required to obtain the final results. (Figs. 74, 75, 76, 77, 78.)

CASE 51.—A. R., Pvt., M. D. Ectropion and partial destruction of upper lid, left; loss of eyeball. Operation March 24, 1919, blepharoplasty and Wolfe graft. (Figs. 79, 80, 81, 82.)

CASE 52.—J. J., Pvt., Co. B, 50th Inf. Cicatricial ectropion, lower lid, right. Operation Wolfe graft from left arm. (Figs. 83, 84, 85.)

Comment on Case 52: It was the opinion of the operators that a free Wolfe (dermic whole-skin) graft was usually more satisfactory in the treatment of ectropion than a pedunculated flap; in the presence of much loss of tissue the latter procedure was utilized, or an epithelial overlay in cases of extensive burns. The consultant in ophthalmology of the Surgeon General's Office was in agreement with this opinion.

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[a] The ophthalmic staff consisted of Capt. (later Major) John M. Wheeler, Captain (later Major) Callan, Captain McDougall, Major W. Weeks, and Lieutenant Barber.

[b] The remainder of the collection of illustrations, as well as records, are on file in the Office of the Surgeon General.

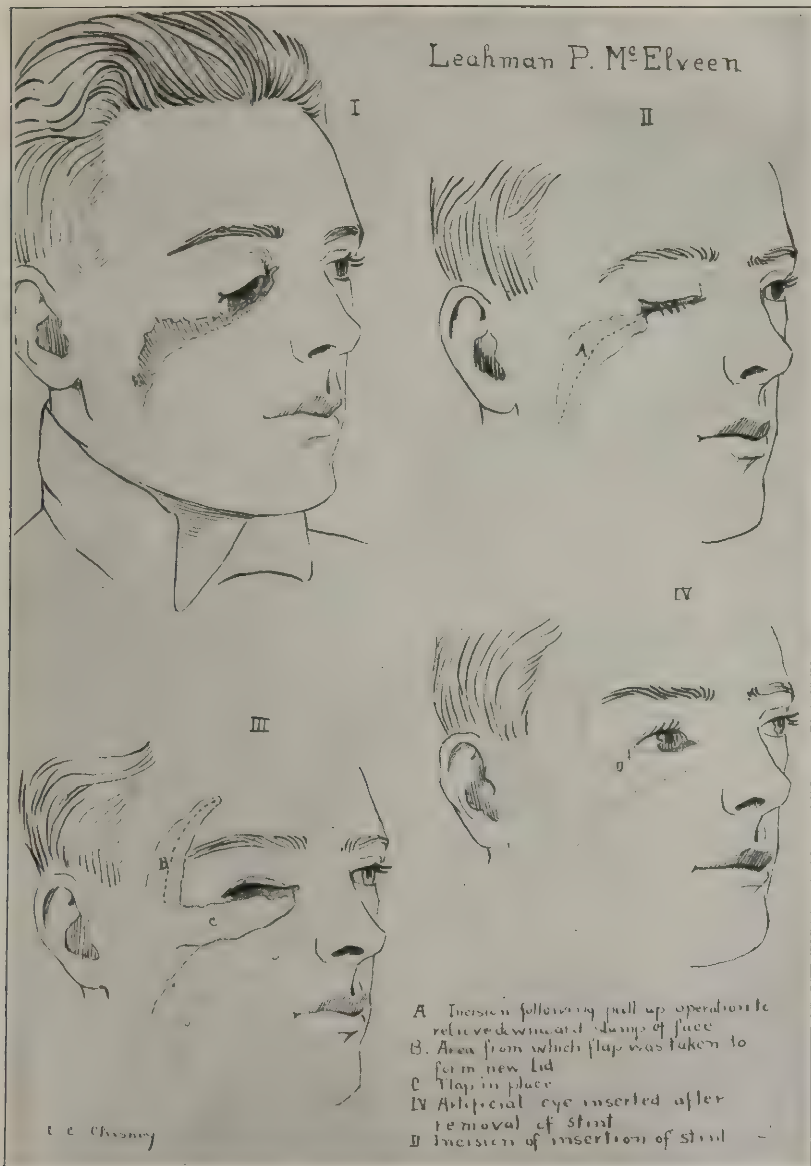

FIG. 65.—Case 47: Schematic drawing of the restoration of eyelid and face.

Fig. 66.—Case 47: First step, the removal of broad scar and pulling up of face. Heavy tension sutures used to support underlying tissues.

Case 53.—E P. M., Pvt., Co. A, 1st Gas Regiment. Gunshot wound, high explosive, in action, Argonne Forest, November 10, 1918, causing fracture of outer part of lower orbital margin; ruptured eyeball. Diagnosis: Cicatricial ectropion of right lower lid with depression of right external canthus. Operation: Advancement of flap. (Figs. 86, 87.)

Case 54.—R. M., age 24, Corpl., Co. L, 109th Inf. Patient was wounded by high-explosive shell while in action in the trenches at the Marne, July 15, 1918. He was received at General Hospital No. 2, Fort McHenry, Md., on April 15, 1919. His eye had been enucleated in a hospital in Germany and he was later (after the armistice) transferred to Base Hospital 115, where a plastic operation was performed. Diagnosis: Deep depression in temporal and malar region, with considerable loss of bony tissue; outer orbital region entirely lost, with large part of outer wall of orbit missing; purulent sinus near outer canthus, notch in upper lid, and laceration of tarsus 8 mm. from canthus. Nipplelike formation in skin of upper lid; considerable loss of lid tissue in

Fig. 67.—Case 47: Pedunculated temporal graft forming new lower lid preliminary to "Esser tunnel" to produce new lower conjunctival cul-de-sac.

Fig. 68.—Case 47: Immediate result, showing complete new lower lid and artificial eye in socket.

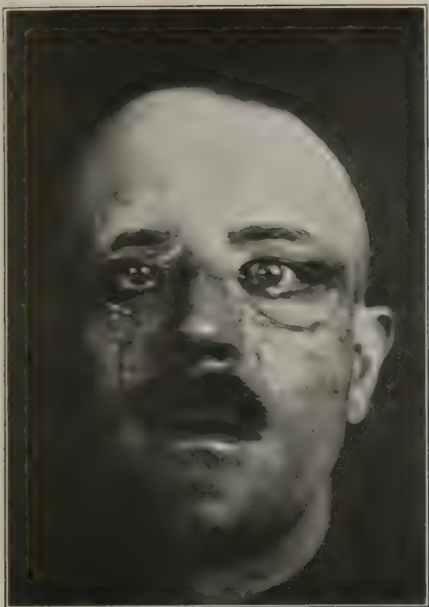

FIG. 69.—Case 48: Burns in aeroplane accident, producing loss of skin surface of eyelids; unable to close lids without eversion.

FIG. 70.—Case 48: Showing dense scars and contraction of lids.

FIG. 71.—Case 48: New upper right eyelid "Gillies outlay" epidermal graft from arm. "Stent" covered with graft buried in left upper lid.

FIG. 72.—Case 48: Two new upper lid surfaces, enabling eyes to close and lids to come in contact with eyeball (case not completed).

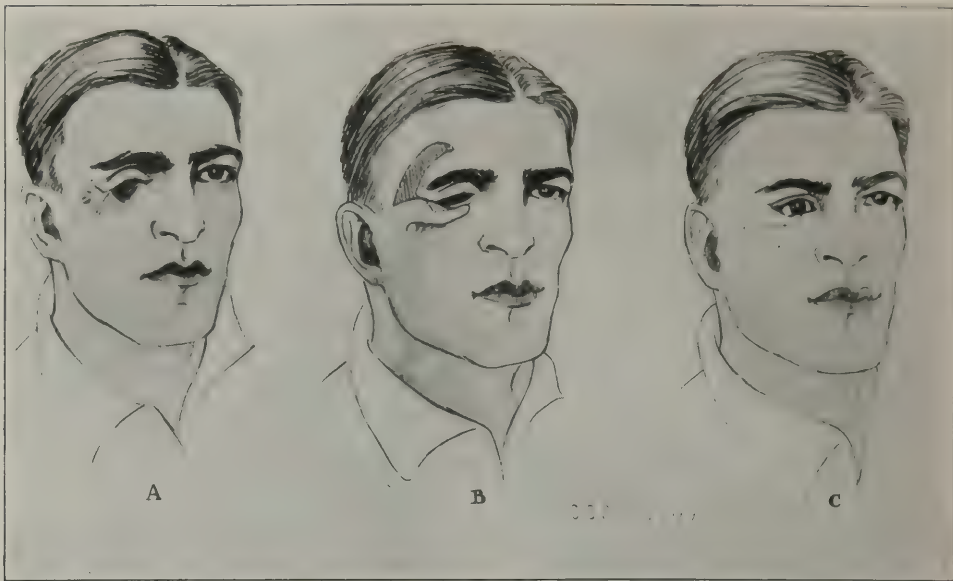

Fig. 73.—Case 49: Photograph of water-color drawing: (A) Gunshot wound, destroying right eye and outer half of lower lid; mucous membrane contracted on cheek by large scar. (B) Area from which temporal pedunculated graft was removed. (C) Pedunculated graft healed, artificial eye in place.

Fig. 74.—Case 50: Gunshot wound; inner half left lower lid and lid border destroyed. Healed scar outer canthus.

Fig. 75.—Case 50: Result of first blepharoplasty; coloboma only partially filled by operation.

FIG. 76.—Case 50: After sliding flap, which was anchored in inner canthus.

FIG. 77.—Case 50: Eyes closed to show covering of eyeball and reconstruction of lid.

FIG. 78.—Case 50: Restoration of lid border completed; scars show direction of sliding flap by which the new lid was obtained.

FIG. 79.—Case 51: Destruction of left upper lid to outer side, not seen in the photograph.

FIG. 80.—Case 51: Wolfe graft in position, lids sutured together to provide bed for graft.

FIG. 81.—Case 51: Showing ability to retain artificial eye; graft healed.

FIG. 82.—Case 51: Final result, showing cosmetic effect obtained.

FIG. 83.—Case 52: Cicatricial ectropion right lower lid with exposure of lower conjunctival lining.

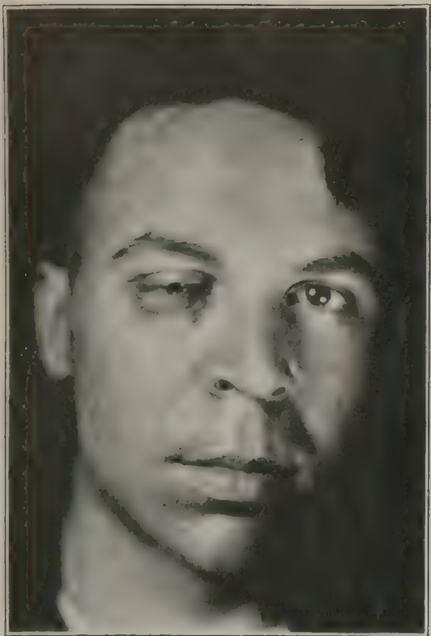

FIG. 84.—Case 52: Free Wolfe graft from left arm in place, healed; lids sutured to maintain base for graft.

FIG. 86.—Case 53: Gunshot wound, high-explosive shell, destroying right eye, part of orbital margin, and producing a cicatricial ectropion and distortion of outer canthus.

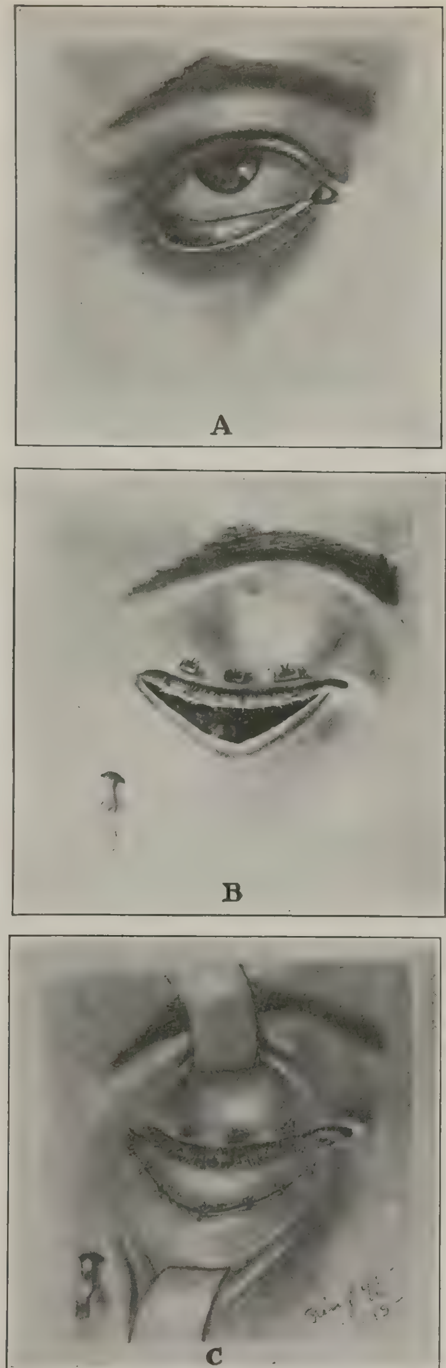

FIG. 85.—Case 52: Artist's drawings of steps in Wolfe graft transplantation: (A) Line of incision shown by dotted lines. (B) Lids sutured, bed prepared for graft, showing undermining of edges, also a drainage wick. (C) Transplanted graft sutured in new bed.

FIG. 87.—Case 53: Sliding flap, advanced forward to raise outer canthus and relax cicatricial tension of lids, permitting the retention of an artificial eye.

FIG. 88.—Case 54: Gunshot wound, high-explosive shell, destroying right eye, outer orbital rim, and bony tissue. Infected antrum draining near outer canthus.

FIG. 89.—Case 54: Fascia lata implantation, right external canthus and temporal region after curettage and drainage of sinus from antrum.

the vicinity of outer canthus. Cicatricial ectropion manifesting itself in outer part of right lower lid. Outer half of eyeball practically gone. Operation May 31, 1919, thorough curetting and drainage of sinus leading from skin near outer canthus into the antrum. Healing uneventful. July 30, 1919. Depressed scar, right temple and orbit. Operation: Fascia lata implantation; satisfactory result. (Figs. 88, 89.)

CASE 55.—C. R., Pvt., D. M. R. Diagnosis: Cicatricial ectropion, lower lid, left. Operation May 22, 1919. Wolfe graft; implantation from left arm. (Figs. 90, 91.)

CASE 56.—L. G., Pvt., Co. L, 354th Inf. March 5, 1919, diagnosis: Cicatricial ectropion of left lower lid. Operation: Wolfe graft to lid from under surface of left arm. May 5, 1919, diagnosis, Cicatricial ectropion lower lid, left. Operation: Plastic. Wolfe graft, right arm.

Comment on Case 56: This case is interesting, as it shows that a Wolfe graft grew in a bed surrounded by cicatricial tissue. Subsequent treatment lessened the deformity. (Figs. 92, 93.)

FIG. 90.—Case 55: Cicatricial ectropion left lower lid.

FIG. 91.—Case 55: Wolfe graft implanted in left lower lid to elevate lid border and relax tension on lower lid.

FIG. 92.—Case 56: Cicatricial ectropion left lower lid.

FIG. 93.—Case 56: Wolfe graft from arm, healed, in area of dense contracted scar.

In order to meet the requirements of certain types of plastic repair the procedures shown in the following descriptions of a series of cases were designed and practiced at General Hospital No. 2.

CASE 57.—Notch of the eyelid associated with laceration of the tarsus "halving" operation McG. received a gunshot wound. Enucleation of the right eye had been performed in France. There was a marked disfigurement of the upper lid in the form of a notch. The tarsus was torn through completely, and imperfect union with scar tissue formation had taken place. A cicatricial band extended upward from the tarsal laceration in the lid substance, and a second band beneath the skin to the nasal side of the notch and independent of it was attached above to the orbital rim. Figure 94 illustrates the outward appearance of the deformity. Operation: The little mass of scar formation in the tarsus was excised, and the tarsal flaps were trimmed to give accurate apposition. Care was taken to excise fully as much tarsus at the upper margin as at the lower margin in each flap of tarsus. The little tongue of skin was trimmed enough for adjustment, and above a small triangular piece of skin was removed, to prevent puckering. The conjunctiva and tarsal flaps were sutured and a mattress suture was carried through the flaps, as shown in Figure 95, and tied after passing through a small rubber plate. Sutures were introduced to give good apposition of the skin flaps. (Fig. 96.) Dissection of the independent band of scar tissue was made through a separate skin incision shown in Figure 97. The lids were then sewed together, so that the lower lid margin would act as a splint for the upper. A rubber tissue dressing was applied. The sutures were all removed in four days.

CASE 58.—Laceration of the lower lid from the inner canthus downward and outward. S. L. received a gunshot wound in action November 1, 1918, in the Argonne Forest. This resulted in rupture of the choroid (left eye), a laceration through the inner canaliculus of left lower eyelid, and fracture of the left malar bone with slightly depressed scars in the malar region. The coloboma of the lid is shown in Figure 98. Two attempts had been made to correct the deformity. A mass of scar tissue was associated with the gap. Operation: All the cicatricial tissue was entirely removed, a most important step of the operation. The incisions required are shown in Figure 98, and were made long enough to insure the possibility of sufficient advancement of the flap, so that the end fell into position without any tension whatever, after most of the sutures had been introduced. Suturing was started at the base of the movable flap and placed in such a way that the interspaces were greater in stationary skin than in the movable lid flap. This difference in spacing was made greatest near the base of the flap, and diminished toward the apex. Proper anchorage of the angle of the lid flap backward and upward was accomplished by carrying the skin sutures through more deeply in the tissues on the nasal side than in the lid flap and by anchoring the apex back to the canthal ligament, carrying the angle of the lid flap as high as possible. A small gauze drain was introduced at operation and was allowed to remain for a few days. The lid flap was split at its edge, as shown in the insert in Figure 99. The conjunctiva was sutured before the skin sutures were placed in the end of the flap. Fine silk thread was used, and the sutures were tied toward the eyeball. Figure 100 shows the method of effecting relaxation. Strips of adhesive were equipped with small hooks. Ordinary dress hooks were entirely satisfactory. Small perforations were made in the adhesive strips and the hooks were slipped through, then the adhesive was turned so as to inclose the base of the hooks, which can not slip through the openings. The adhesive strips were placed so that the proper traction was produced, which gave relaxation of the flap. A rubber band was strung between the hooks to produce tension. The skin sutures were removed in four days, to prevent the possibility of pus formation about them, and to prevent suture scars, but the relaxation apparatus was kept on for 10 days to 2 weeks to assure strong union, with the eyelid in the proper position. Figure 101 shows the final result.

CASE 59.—Laceration of lower lid near inner canthus with coloboma and cicatricial ectropion. Pvt. T. R. received a gunshot wound, causing a laceration through the lower canaliculus of the right eyelid, a marked ectropion, a large coloboma, and a heavy mat of scar tissue overlying a fracture of the superior maxillary bone. (Fig. 102.) Operation: The mass of scar tissue was excised and several small foreign bodies were removed. A free canthotomy was performed and an incision was carried upward and outward from the outer canthus. Figure 103 shows the lid flap that was shaped, the drain, and the skin sutures in place. After all scar tissue had been dissected out an incision was carried downward and outward, and a triangle was removed from the lower flap at the temporal end of this incision. In making this deep downward and outward incision it

FIG. 94.—Case 57: Notch in upper eyelid due to laceration through the tarsus.

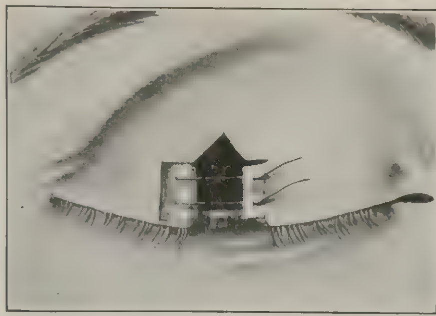

FIG. 95.—Case 57: "Halving" operation. Dissection has been made. Mattress suture is shown passing through denuded tarsus on temporal side and flap of skin on nasal side.

FIG. 96.—Case 57: "Halving" operation. Lid everted. Conjunctival sutures ready to tie.

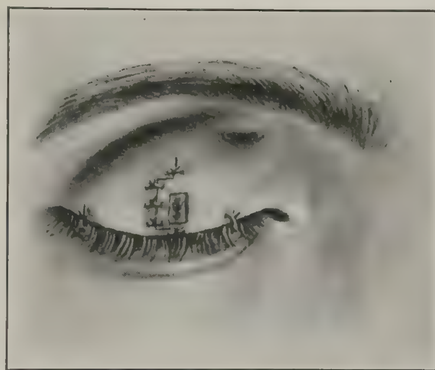

FIG. 97.—Case 57: "Halving" operation. Sutures tied. Mattress suture passed through rubber plate. Upper and lower lids sutures together.

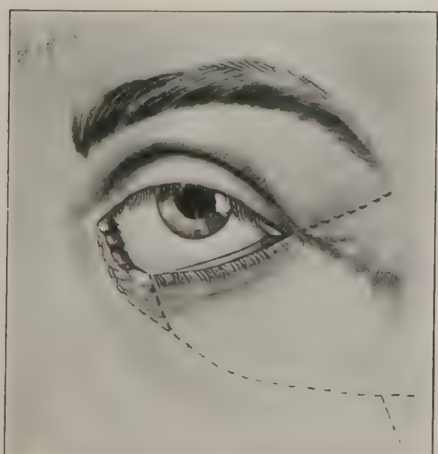

FIG. 98.—Case 58: Fracture of orbital margin. Laceration of lower lid from inner canthus downward and outward. Dotted lines show position of incisions.

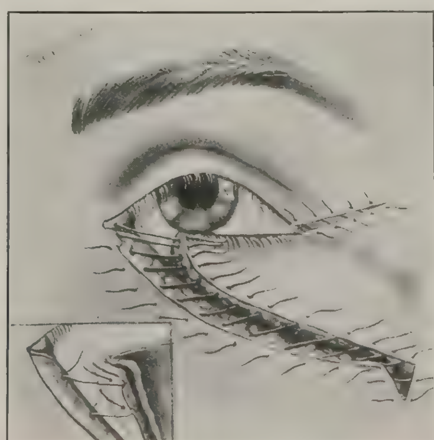

FIG. 99.—Case 58: Sutures introduced for advancement of lid flap. Insert shows splitting of margin of flap.

FIG. 100.—Case 58: Method of maintaining relaxation of lid flap during healing process.

FIG. 101.—Case 58: Photographic appearance three weeks after operation.

FIG. 102.—Case 59: Laceration through lower canaliculus near inner canthus. Marked ectropion, coloboma, and heavy mat of scar tissue overlying fracture of superior maxillary bone.

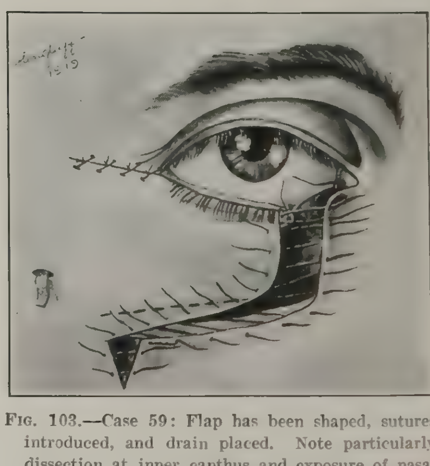

FIG. 103.—Case 59: Flap has been shaped, sutures introduced, and drain placed. Note particularly dissection at inner canthus and exposure of nasal end of tarsus, which is to slip behind little skin of flap.

was curved in a slanting (beveled) fashion, instead of directly backward at right angles to the skin surface. Figure 104 is a photograph taken one week after operation to show the lower eyelid in place.

CASE 60.—Coloboma at the outer canthus. Corpl. F. G. was wounded by high explosive in action on September 21, 1918, at St. Mihiel. Fracture of the left malar bone resulted, with wounds of soft parts in the malar region, also a rupture of the left eye, for which enucleation was performed. On admission to General Hospital No. 2, Fort McHenry, the left eyelids were widely separated at the outer canthus. The outer part of the lower lid was everted, and heavy depressed scar formation extended back 1½ inches from the outer end of eyelids. Operation March 22, 1919: The mass of scar tissue was largely excised, and the skin widely undermined in both upper and lower flaps. Subcutaneous grafts were everted on pedicles and sutured in position to fill in the depressed area. A subcutaneous graft was turned on the external orbital margin, and to this the conjunctiva was sewed. Another graft was turned over on the first, overlapping it in such a way that the nasal margin of the flap would shelve over the graft underneath. To the second graft the skin was sutured at the temporal ends of tarsi to make an outer canthus. In this way the cul-de-sac was made behind the newly formed canthus. The flaps in the malotemporal region were brought together by silk sutures. Figure 105 shows the operative field after the mass of scar tissue had been removed, and the skin trimmed, and with the pedunculated grafts turned into the depressed area. Figure 106 illustrates the appearance of the outer canthus two and one-half months after operation. Figure 107 is a photograph of the same patient before discharge from the hospital.

FIG. 104.—Case 59: Photographic appearance after operation, showing lower eyelid in position.

FIG. 105.—Case 60: Subcutaneous pedunculated flaps turned to fill in a depression in malar region and to obtain adjustment of conjunctiva and skin to secure restoration of cul-de-sac and canthus.

The following cases, taken from a number reported from General Hospital No. 2, Fort McHenry, illustrate the results of various types of orbital implantation:

CASE 61.—F. L., Corpl., Co. M, 142 Inf. Right eyeball enucleated because of ruptured sclera; fascia lata implantation. (Fig. 108.)

CASE 62.—I. B. F., Pvt., Co. C, 145 Inf. April 8, 1919. Foreign body in left shrunken globe. Operation: Enucleation followed by fat implantation taken from abdomen. (Figs. 109, 110, 111.)

CASE 63.—J. D., Pvt., G 808—P. Inf. March 10, 1919. Ruptured globe, right. Operation: Enucleation, followed by implantation of glass ball in Tenon's capsule. (Fig. 112.)

CASE 64.—R. H., Sgt., D 312, M. T. C. May 6, 1919. Iridocyclitis right eye. Enucleation followed by glass ball implantation in Tenon's capsule. (Figs. 113, 114.)

CASE 65.—H. H., Pvt., 30 R. R. C. Phthisis bulbi, left. April 21, 1919. General Hospital No. 2, Fort McHenry. Operation: Enucleation and fascia lata and sphere of fat implantation. Fat was caught up with silk and the sphere and fascia were made to cover eyeball. Left eye was

removed and each muscle caught with a pair of forceps. The two obliques were sutured to the sphere at approximately an anatomical position, and the sphere then placed into position in Tenon's capsule. Four recti were next sutured in position, and the conjunctiva closed over the implant to make a horizontal wound. The reaction from the operation was mild, and in about 10 days the wound opened and a part of the fat and fascia lata sloughed. Healing by granulation, good stump resulted. (Fig. 115.)

FIG. 106.—Case 60: Appearance of cul-de-sac and outer canthus two and one-half months after operation.

July 8, 1919. Exophthalmometer readings: O. D. 18, O. S. 23.

	In.	Out.	Up.	Down.
Rotations, O. D.....	44	63	32	60
	15	8	10	12

CASE 66.—S. H., Pvt., Co. A, 109th M. G. B. Cicatricial right orbit due to gunshot wound. Upper and lower conjunctival sacs restored by means of epithelial graft (Thiersch wrapped about a mold of "stent"). (Figs. 116, 117.)

The following case history will illustrate the use of subcutaneous pedunculated grafts:

CASE 67.—I. A., Pvt., Co. L, 322d Inf. On November 9, 1918, in the Argonne, patient was struck by machine-gun bullet, producing gunshot wound left side of face; entrance below left eye, emerging right cheek. Admitted to General Hospital No. 2, Fort McHenry, Md., March 15, 1919. Diagnosis on admission: Left eye has been enucleated. Marked thickening, left lower eyelid. Just below lid, depressed scars associated with fracture of superior maxilla. Operation: March 21, 1919. Skin of lower lid dissected up and most of thickened tissue removed. Most of scar tissue dissected out from area of fracture. Subcutaneous flap from cheek turned into depression. Skin incisions for plastic adjustment. Operation resulted in decided improvement in appearance. (Figs. 118, 119.)

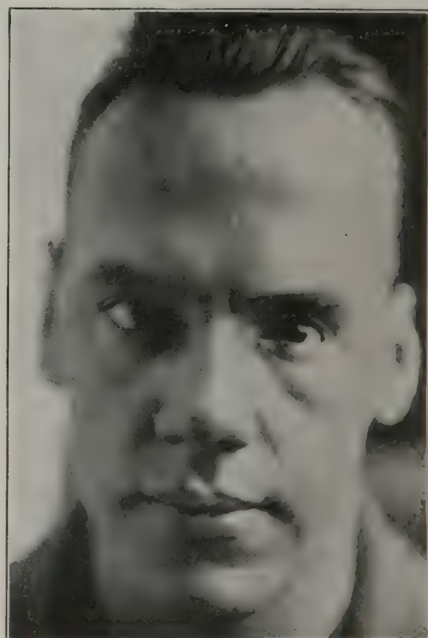

FIG. 107.—Case 60: Photographic appearance with artificial eye before patient was discharged from hospital.

The following case illustrates the restoration of a cicatricial orbit and loss of inner third of lid by means of sliding flap and Thiersch grafts:

CASE 68.—L. C., Pvt., Co. G, 23d Inf. Patient admitted to General Hospital No. 2, Fort McHenry, with cicatricial orbit and partial destruction of lower lid, the result of a gunshot wound. Operation January 6, 1919. Contracted socket restored by means of Thiersch grafting after proper dissection, and defect of lower lid repaired, after removing scar tissue, by sliding skin flap into inner angle. (Figs. 120, 121.)

CASE 69.—J. C., Pvt., Co. G, 132 Inf. Admitted to General Hospital No. 2, Fort McHenry, for obliterated right cul-de-sac. Operations May 23, 1919, consisted of an epidermic inlay, the graft having been taken from the left thigh. Two weeks later the mold of "stent" was removed, and the sac found to be restored. (Figs. 122, 123.)

FIG. 108.—Case 61: Result after enucleation, followed by fascia lata implantation.

FIG. 109.—Case 62: Cosmetic result. Eyes in primary position.

FIG. 110.—Case 62: Eyes directed to right.

FIG. 111.—Case 62: Eyes directed to left.

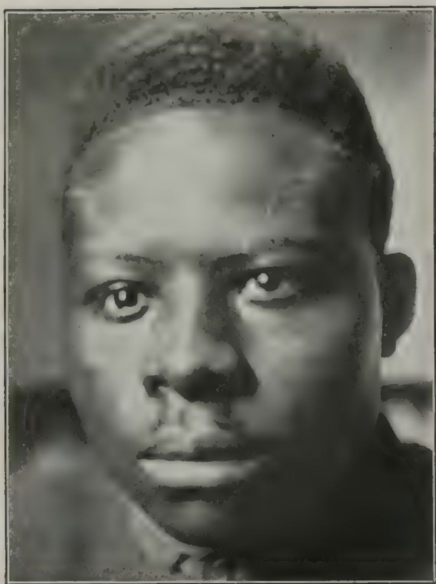

FIG. 112.—Case 63: Cosmetic result after implantation of glass ball in Tenon's capsule.

FIG. 113.—Case 64: Result after glass ball implantation, following enucleation; eyes in primary position.

FIG. 114.—Case 64: Enucleation followed by implantation of glass ball; eyes directed to right; unusually good outward movement of prosthesis.

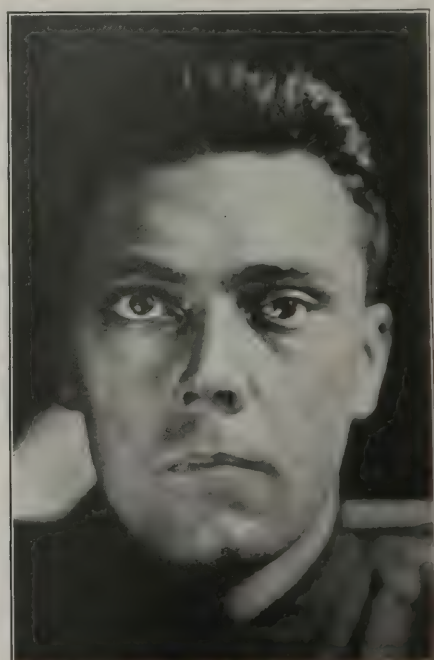

FIG. 115.—Case 65: Result after fascia lata and fat implantation.

FIG. 116.—Case 66: Condition prior to operation.

FIG. 117.—Case 66: Two months after operation: artificial eye in place.

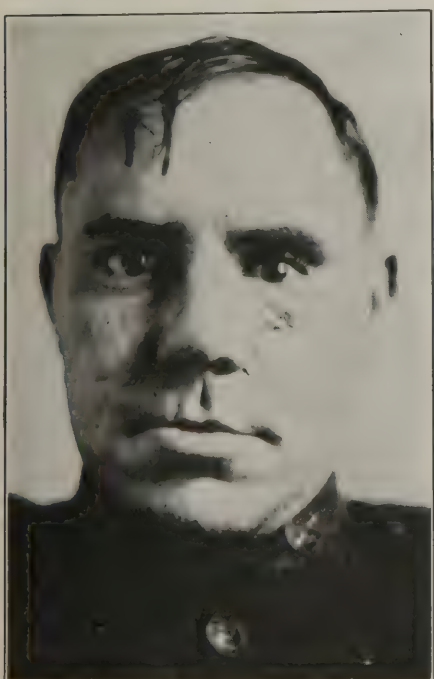

FIG. 118.—Case 67: Condition on admission; thickened lid, depressed scars, fractures of superior maxilla.

FIG. 119.—Case 67: Condition two months after operation.

Fig. 120.—Case 68: Condition on admission; cicatricial orbit; partial lid destruction.

Fig. 121.—Case 68: Result four months after operation.

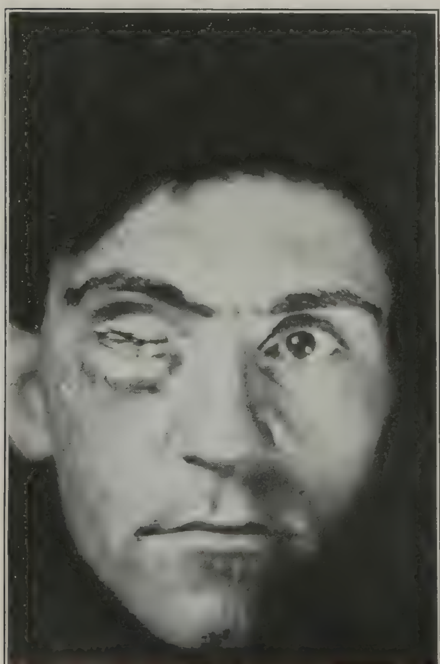

Fig. 122.—Case 69: The form covered with epidermis has been implanted.

Fig. 123.—Case 69: The "stent" mold has been removed and the artificial eye is in place.

CASE 70.—C. C., Pvt. F. C., Co. B, 313 T. A. October 12, 1918, in the Argonne, patient was struck by piece of shell, wounding right lower eyelid, fracturing superior maxilla, and producing wound of shoulder. Admitted to General Hospital No. 2, Fort McHenry, March 15, 1919. Diagnosis on admission: Heavy, depressed scar of cheek, fractured orbital margin. Marked ectropion, mass of scar tissue outer part of right lower lid at margin. Scar in macula; detachment of retina. First operation March 21, 1919, Wolfe graft. Graft took well. Repair of lid margin was left for subsequent operation. Distortion of lid and slight ectropion. Second operation May 22, 1919, plastic for restoration of temporal portion of lid margin. Scar tissue dissected away. Lid margin split. Diverging skin incisions. Triangle of tarsus and conjunctiva removed near outer canthus and sutured with paraffin silk. Skin flaps advanced to meet each other at a point a few millimeters nasal to sutured wound in tarsus. Adherent scar formation much improved by galvanism and massage. (Figs. 124, 125, 126, 127.)

CASE 71.—E. T., Corpl., Co. K, 101st Inf. Patient admitted to General Hospital No. 2, Fort McHenry, because of loss of eye and lower lid margin. Operation May, 1919: Transplantation of free skin graft from eyelid and eyebrow.

Comment on Case 71: This case history and its illustrations have been selected in order to show the utilization of the eyebrow in restoring the ciliary margin. In the absence of both eyebrows, the flap may be taken from the occipital region. (Figs. 128, 129, 130.)

The restoration of the marginal portion of the eyelid by a free graft from the lower part of the eyebrow is further illustrated by the following case, which was reported from General Hospital No. 2, Fort McHenry.

FIG. 124.—Case 70: Condition on admission; ectropion and scar formation.

CASE 72.—C. H., age 37, a sergeant in the Air Service, serving as a mechanic in the overseas Army, met with an accident March 29, 1918. He was melting lead in a ladle, and a piece of iron fell into the hot lead, causing it to splash. The right eye was struck by molten lead, and was so badly burned that it was enucleated a week after the accident. During the following few weeks four operations of a plastic nature were performed in France. June 30, 1919, this patient was admitted to General Hospital No. 2, Fort McHenry, Md. On admission his condition was as follows: On the right side there was no sign of a lid margin above or below; there were no eyelashes, and the marginal portions of both upper and lower lids were absent; there was no sign of a tarsal plate above or below; only irregular folds of skin remained to suggest eyelids. The canaliculi had been thoroughly slit and were open, so that their mucous membrane lining was exposed. The conjunctiva had entirely disappeared, and there were no cul-de-sacs. Between the folds of lid skin there was exposed a small plaque of epidermis about 20 mm. long and 12 mm. wide, which had been grafted on the orbital contents. (Fig. 131.)

First operation, July 8, 1919: Local anesthesia (novocaine and adrenalin). An incision through the skin of the upper lid was made 3 mm. to 4 mm. from its margin and about 40 mm. long. (Fig. 132.) The skin below the incision was unrolled, and bands of scar tissue were removed. Next, paraffined silk sutures were passed through the skin fold near the cut margin, and by means of

these the skin fold was tacked down to the plaque of skin presenting on the orbital contents, and the denuded fusiform area to receive the graft was thus held on the stretch. Next, a fusiform dermic graft was dissected free from the lower part of the right brow and the skin below it. (Fig. 133.) This graft was 45 mm. long and 8 mm. wide in the center. The graft was placed on a little pad of gauze, soaked with warm saline solution, raw surface upward, and with the scissors tags of subcutaneous tissue and muscle fibers were removed. As soon as the graft was prepared it was put in place in its bed, upside down, so that the hair line would be in proper position to mimic eye lashes. With fine paraffined silk sutures the graft was sewed in place. Then, after slight undermining of the skin, the wound occasioned by removal of the graft was sutured. (Fig. 134.) A very small amount of sterile vaseline was smeared over the graft and the wounds; rubber tissue was placed over all, and gauze fluff was packed evenly over the rubber tissue. Strips of adhesive plaster were placed so as to hold the dressing snugly, and firm pressure was obtained by bandaging. The dressing was left undisturbed for five days.

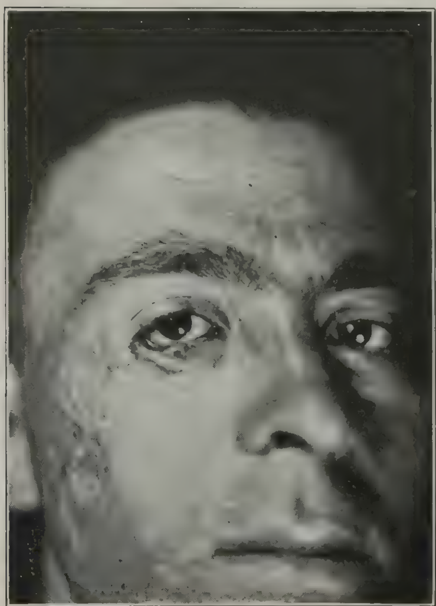

FIG. 125.—Case 70: Wolfe graft successfully in place.

FIG. 126.—Case 70: Result after restoration of temporal portion of lid margin.

On July 13, the dressing and rubber tissue were removed. The graft had taken completely. The sutures were removed, and rubber tissue and dressing were replaced. Ten days after operation the dressing was left off and the graft was kept anointed with a very small amount of sterile vaseline, and protected by a shield.

Second operation, July 22, 1919. Restoration of the marginal portion of the lower eyelid. Local anesthesia. The preparation of the bed for the reception of the graft for the lower lid was like that in the upper (Fig. 135), but tissue had to be supplied for this lid, therefore the graft was larger (50 mm. long and 20 mm. wide in the center). This graft was taken from the lower part of the left eyebrow and the skin below it. After removing the slight amount of subcutaneous and muscle tissue that was taken with the skin, it was placed with the hair margin up to supply shading at and near the new lower lid margin. This graft also "took" completely.

Third operation, August 5, 1919. Restoration of the cul-de-sacs. Ether anesthesia. The little plaque of grafted skin was left adherent to the orbital contents, and an incision was made around its margin. The dissection was carried to the periosteum at the orbital margin. A mold of

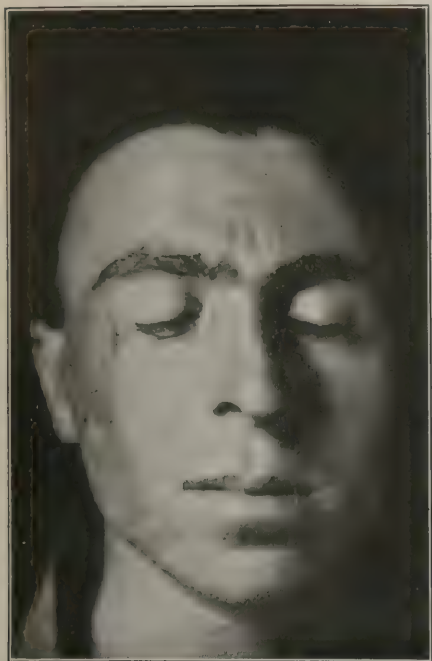

FIG. 127.—Case 70: Accurate approximation of lids as result of operation.

FIG. 128.—Case 71: Condition on admission; loss of lower lid margin and cicatricial socket.

FIG. 129.—Case 71: Showing graft in place and lines of incision along brow; early stage; stitches still in place.

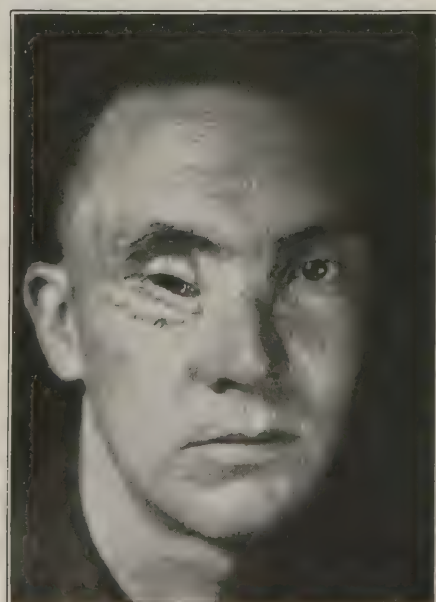

FIG. 130.—Case 71: Condition 16 days after Figure 129 was taken; graft has taken; case not complete.

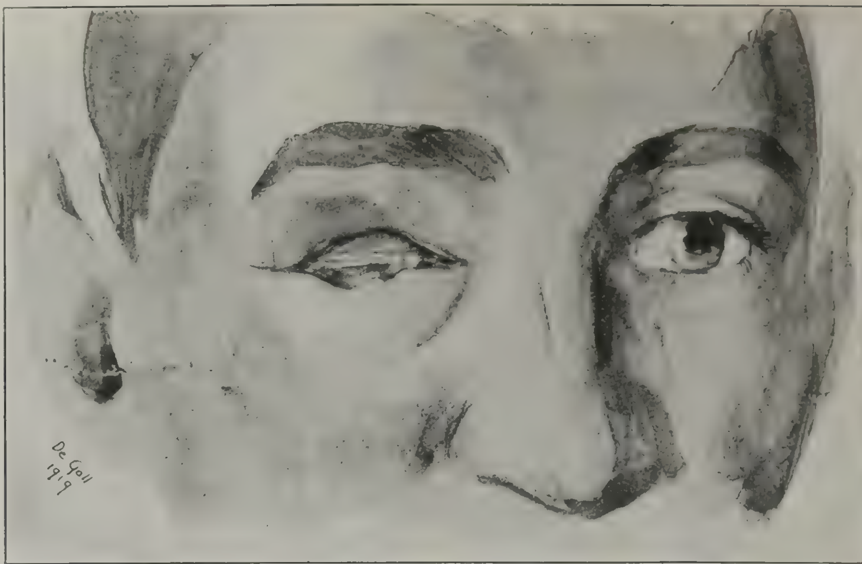

Fig. 131.—Case 72: Photograph of water color to show condition before operation. On right side lid margins are entirely gone. Cilia, tarsal plates, and conjunctiva have been completely destroyed. Between the palpebral folds of skin can be seen a plaque of grafted epidermis, the result of old attempts to restore the cul-de-sac.

Fig. 132.—Case 72: Before operation. Dotted lines in upper and lower folds indicate primary incisions.

Fig. 133.—Case 72: Bed prepared for upper graft. Skin below primary incision has been unrolled and put on the stretch by sewing it to orbital contents. Graft from lower part of brow is being taken to place over denuded area.

Fig. 134.—Case 72: Graft from lower part of brow has been turned upside down, so that hair line is along its lower margin and graft is sutured in position.

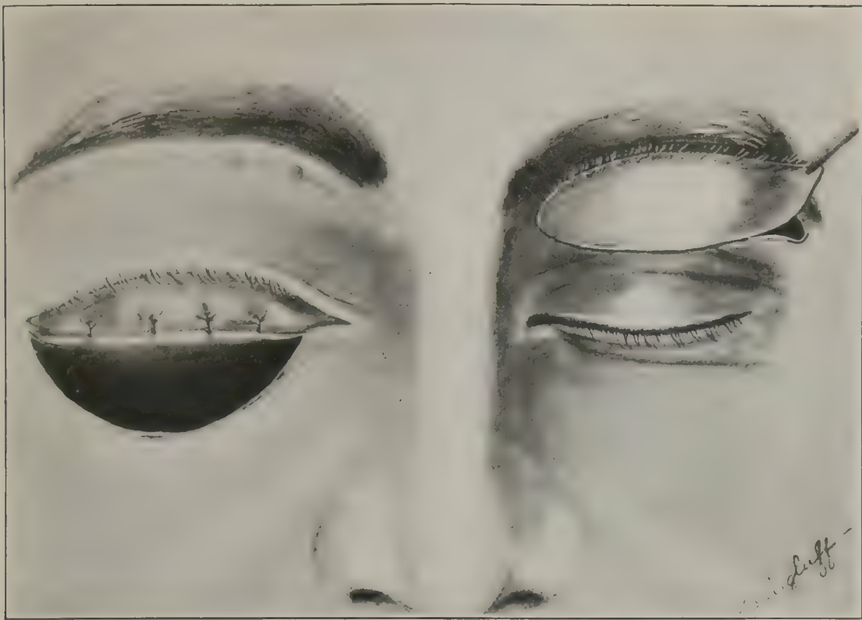

Fig. 135.—Case 72: Dissection made for preparation of bed to receive lower graft. Graft being taken from lower part of left eyebrow, to be placed (hair margin upward) over denuded area.

dental impression-compound was made to fit the cavity, and was completely covered with Thiersch grafts, raw surface outward. This was placed in the cavity made by the dissection, and both upper and lower cul-de-sacs were restored at one operation. This resulted in a complete "take," and no granulation tissue appeared. The disfiguring mucous linings of the slit canaliculi were dissected out and the little flaps were sewed together for obliteration of the canaliculi.

Fourth operation, January 7, 1920. Repair at outer canthus and trimming of lid margins. Local anesthesia. After healing from the grafting operations, the patient was able to wear an artificial eye acceptably, but the fissure was a little too long for the best cosmetic effect, and the new-formed lid margins were slightly uneven. The palpebral fissure was shortened about 3 mm., and the lid margins were made straight and even.

Fifth operation, February 4,. 1920. Fat implantation into the orbit. Ether anesthesia. This operation was performed to fill in the socket, as it was somewhat sunken, and to furnish as much motility of the stump as possible. The fat was taken from the abdomen and placed inside the muscle cone. Healing was uneventful. (Fig. 136.)

Fig. 136.—Case 72: Photograph of patient taken fours weeks after final step of operative procedures.

METHOD OF RESTORING AN OBLITERATED SOCKET.

Although contracted sockets, complications frequently encountered after the wounded men from France began to arrive in this country, were treated by various well-known operative procedures, the one most commonly employed, and with great success, concerned itself with the use of Thiersch grafts held in place by means of molds of "stent" (dental modeling composition). In general terms, the method was as follows:

An external canthotomy was first performed. Next, with a small scalpel the new cul-de-sac was formed, keeping close to the skin so that the new lining for the lid should be approximately in the same position as the destroyed conjunctiva. The incision was carried down so that the bottom of the cul-de-sac was on a line with the lower margin of the orbit. Bands of dense scar tissue between the lid and the orbital tissues were excised as thoroughly as possible from the inner surface of the lid. In the formation of the upper cul-de-sac the incision was carried to the roof of the orbit, maintaining as far as possible the normal thickness of the lid. The graft was cut from the anterior surface of the thigh by means of a razor in one piece large enough to cover the form around which it was wrapped. The graft was quite thick, considerably thicker than the classical Thiersch graft. The form about which the graft was wrapped was made from Kerr's dental modeling compound, so that it should fit the cavity snugly, and when pressed into it, the straight lower or upper border, as conditions required, should reach the edge of the lid. The form was prepared before the graft was cut and in the case of the lower cul-de-sac the lower border was made convex and the upper straight with two notches in the upper straight edge of the form at about the junction of the outer and middle thirds and middle and inner thirds. The same style form was used in the upper cul-de-sac.

The two sutures which hold the form in the cul-de-sac were next introduced. A silk suture with two needles, one needle curved and one straight, were used. The curved needle was passed back into the orbital tissues at a point corresponding to the border of the lid, and was passed down or up to the lower or upper wall of the orbit, according to existing conditions. In the case of the lower cul-de-sac, the suture was brought out through the skin below the lower margin of the orbit. The curved needle in the case of the upper cul-de-sac was brought out just above the eyebrow. The straight needle was passed through the edge of the lid and immediately beneath the skin, to emerge a short distance from the other. The graft was next cut and wrapped about the form. The convex edge of the form was placed in the middle of the graft and the two free edges of the graft overlapping slightly on the straight edge of the form. The form wrapped in the graft was held in a pair of tissue forceps at its straight edge, and the sutures were slipped over the ends into the two notches and the form pressed into the cul-de-sac while an assistant tightened the sutures. The form was thus pressed into the bottom of the cul-de-sac. The sutures were then tied over a piece of small rubber tubing. Both cul-de-sacs were restored at the same time. The dressing remained for four days, when the sutures and form were removed, and a large temporary reform eye was inserted. This was removed once every twenty-four hours, and the cul-de-sac washed out. This method was employed especially in General Hospitals No. 2 and No. 11.

TRAUMATIC DACRYOCYSTITIS.

This condition was encountered not infrequently, and the following cases of this affection are condensed from a report submitted by the chief of the ophthalmic staff on duty at General Hospital No. 2, Fort McHenry.

CASE 73.—S. J. received high-explosive shell wounds which occasioned the loss of his left eye and injury to the bony and soft tissues of the upper part of the face. Among these were wounds in the region of the left lacrymal sac, particularly the structures in front of the lacrymal groove. (Figs. 137, 138.) To fill in a depression in this region a surgeon had performed a skin plastic operation. Following this operative procedure, redness, thickening, edema and purulent discharge from the wounds persisted for a month, hence extirpation of the sac was performed. After cutting through a mass of scar and granulation tissue, the anterior crest of the lacrymal groove was reached. Inflammatory tissue partially surrounded the sac wall, which was thickened but not badly injured. In dissecting the nasal wall of the sac from the periosteal lining of the lacrymal groove a most interesting condition revealed itself. A small pustule lay between the lacrymal sac and its bony groove, at which position the periosteum was absent; and within the pustule was a minute metallic foreign body. At a corresponding point there was a miniature crater-like formation on the superior maxillary bone just in front of the suture in the groove. This consisted of a little bony elevation with a minute facet, which lodged the particle. The tear sac and the diseased tissue which surrounded it were dissected out. The cavity was swabbed with tincture of iodine and sutures of paraffined silk were placed to close the wound. Healing was uneventful, and with the source of trouble removed, the tissues soon became soft and pliable. Three weeks after extirpation of the sac it was safe to operate in this region, and a glass sphere was planted in the orbit to overcome sinking of the orbital tissues, and the artificial eye made a presentable appearance.

FIG. 137.—Case 73: Gunshot wound in the region of the left lacrymal sac has resulted in dacryocystitis. A pustule between the lacrymal sac and its groove contained a small metallic foreign body.

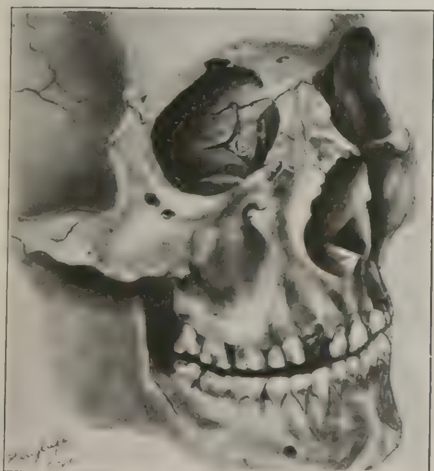

FIG. 138.—Case 73: Halftone drawing of the skull, featuring the lacrymal groove. The anterior crest of this groove is the most important landmark in the removal of the lacrymal sac. (A) Anterior crest of groove. (B) Posterior crest.

FIG. 139.—Case 74: Left inner canthus has been drawn down by cicatricial contraction. The dotted line indicates the position of the primary incision.

CASE 74.—G. G. (Fig. 139.) This case illustrates how far from the ordinary position, with reference to the soft parts, it may be necessary to place the primary incision for removal of the tear sac in a traumatic case. The inner canthal ligament was torn away, and the inner canthus was pulled well down from its original position. The lacrymal groove was not badly damaged and the sac remained almost in place. The position of the primary incision is indicated by a dotted line.

Case 75.—S. N. received machine-gun bullet wounds, which resulted in injury to both orbits and structures about the nose. (Fig. 140.) Both eyes had been removed, and most of the tissues of the upper part of the nose had been lost. There was a large exposure of the nasal mucous membrane, and there was no skin at the inner canthi. On the right side, openings into the ethmoid cells and antrum existed, and numerous polyps had sprung up. The right lacrymal drainage system was entirely gone. On the left side there was a purulent dacryocystitis, and as a result the tissues about the sac were bathed in muco-pus. No bony landmarks about the sac could be felt distinctly, and there was a coloboma at the inner canthus. On March 17, 1919, an incision about 15 mm. long was made through the conjunctiva in the inner canthal region. The dissection was carried through granulation and scar tissue, and the lacrymal sac was found in the mass. Evidently there had been no perforation of its wall, in spite of the extensive mutilation and exposure of the tissues about it. Much of the deep fascia and periosteum which normally surround the sac remained, and from these it was dissected free. The neck of the tear sac and the upper part of the duct were found to be greatly dilated, and these were removed with the sac wall. The posterior crest of the lacrymal groove was found to be intact, and a little of the lacrymal bone in front of it remained. This, with the anterior part of the os planum of the ethmoid, was movable, but the bony tissue seemed to be firm and healthy, and so it was left. The wound was sutured, but a small gauze drain was left in the lower end. Healing took place uneventfully, and the drainage stopped completely.

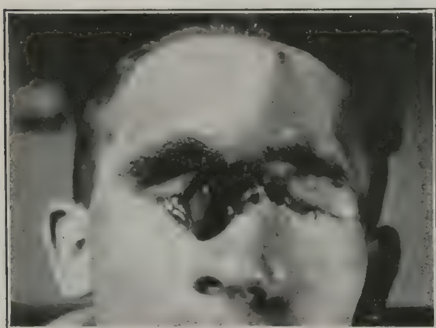

Fig. 140.—Case 75: Severe traumatism in region of lacrymal sacs. The landmarks for the removal of sacs have disappeared.

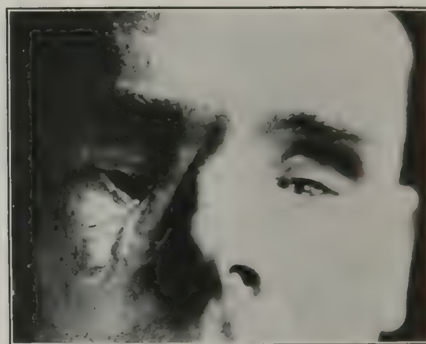

Fig. 141.—Case 76: In this case the right lacrymal sac has been badly injured and its cavity has become part of a large pus-filled cavity of the upper part of the nose.

Case 76.—H. E. K. (Fig. 141) was wounded September 28, 1918, in action near Verdun. He was struck on the left side of his face by fragments from a high-explosive shell and received serious wounds of both orbits. A piece of shell entered the left orbit, rupturing the left eyeball, passed through the nasal cavities, and emerged from the right orbit and cheek. As a result of this severe traumatism, the sight was lost in the left eye, the right eye was removed on account of rupture; the lower lid on the right side was badly lacerated, and a cicatricial ectropion developed; there was double purulent dacryocystitis, which made it unsafe to proceed with plastic repair of the right side; the upper part of the right nasal cavity was occluded, and there was almost complete occlusion of the left nasal cavity.

On May 28, 1919, under ether anesthesia, the left lacrymal sac was removed. It was found embedded in scar tissue. Most of the lacrymal groove had been shot away, but the anterior crest and a small amount of the superior maxillary portion of the groove remaining was covered with periosteum. The communication in the nose was thoroughly curetted, a gauze drain was inserted, and a gauze dressing and pressure bandage were applied. Prompt healing took place.

On June 8, 1919, the right lacrymal sac was extirpated. An incision was made to the nasal side of the inner end of the right upper eyelid. (The lower lid had been torn away from the inner canthal ligament.) A mass of scar tissue was removed and the thickened wall of the tear sac was found. An attempt to dissect out the sac wall led to the discovery that its cavity was only a small part of a large cavity in the upper part of the nose. The shell fragment had left a free communication through the nasal process of the superior maxilla, the lacrymal bone and the os planum of the ethmoid, and a wall of granulation tissue had formed. This wall rested on the nasal septum

and its cavity was filled with mucous and pus from the lining of the lacrymal sac. The entire wall of the pus-filled cavity was dissected out along with the lacrymal sac and scar tissue, and a gauze drain was placed in the cavity and a pressure dressing was applied. The healing from this operation was uneventful.

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SECTION IV.

OPHTHALMOLOGY IN THE AMERICAN EXPEDITIONARY FORCES.

INTRODUCTION.

The World War demonstrated in all of its activities that through specialization results were accomplished which otherwise would have been unattainable. True as this was for the entire Army, it was especially essential in the professional work of the Medical Department. Soon after our entry into the conflict it became apparent that the Medical Department would have to call to service many physicians and surgeons who were trained specialists in their particular branches of our profession. Of these branches ophthalmology was one of the most important, it being among the oldest and most distinct specialties and one that the average physician knew little about. It was therefore logically one of the first to impress on the Medical Department of the Army the need for its adequate recognition. It was at that time estimated that at least 500 trained ophthalmic surgeons would be necessary to carry on successfully the ophthalmic work to be required in this country and abroad. The selection and enrolling of the officers required is a wonderful history in itself, but does not concern us here other than for a word of appreciation of the excellence of that work, which was the foundation stone on which was erected the efficient ophthalmological organization later built up in this country and abroad.

Before our entry into the conflict, even as far back as 1915, several American ophthalmic surgeons had voluntarily seen service with the British and French, and, while the ophthalmic work they saw and did can not be included in this history, their experiences were of value in pointing out the problems our ophthalmic surgeons would necessarily have to meet and solve.

An historical review of some of the accomplishments of our ophthalmic surgeons who went to France and England, especially with reference to the clinical and pathological ophthalmic problems which were encountered, naturally begins with the sailing from this country, in the spring of 1917, of the base hospital units which went to the aid of the sorely tried British Medical Service. It is true that the first ophthalmic problems presented to them were related to the treatment of the British soldiers, but these surgeons were enrolled in our Medical Department and were working for the common cause. Their experiences were varied, and those who had the entrée to Colonel Lister's clinic at Boulogne acquired a knowledge of military ophthalmology that later was of untold value to our own service. Shortly after beginning the work with the British Expeditionary Forces these surgeons began to receive some of our own soldiers who were training under the British behind the trenches, and were thus able to apply, in the treatment of American soldiers, some of their earlier-acquired knowledge.

With the beginning of the transportation of our fighting forces to France and England other base hospitals followed, this time for duty with our own troops. The officers in charge of the ophthalmic service in these units were mostly young men of sterling worth and well trained. The work they accomplished under many handicaps is worthy of special note.

A résumé of the clinical work of the ophthalmologists in the American Expeditionary Forces would not be complete without some reference to their work outside of their special field. Many of these officers did yeoman service as surgical assistants or as dressers in the wards, or even took charge of surgical cases both in the operating room and in the wards. To enable them to do this to the best advantage, the following circular was sent from the headquarters of the medical and surgical consultants to the commanding officers of hospitals:[1]

1. With a view to expediting the care of soldiers with eye injuries without interfering with the routine work of the surgical teams at mobile and evacuation hospitals, and also in order to keep the ophthalmic surgeon assigned to these hospitals employed in a position where his services will be available when necessary, it is recommended that commanding officers of evacuation and mobile hospitals be directed to carry out the following:

(*a*) That the ophthalmic surgeons who are appointed to mobile and evacuation hospitals be assigned as regular assistants on one of the permanent surgical teams, their duties to be those of regular surgical assistants, except in cases of ocular wounds or injuries, when the chief of the team will in turn assist the ophthalmic surgeon in the performance of the necessary eye operation.

(*b*) That the triage officer be instructed to direct patients with eye injuries to this particular team for operation. When this team is not on duty, cases with eye injuries alone should be sent to a ward and held for them. The same should apply to patients having other wounds in addition to the ocular injury, except in cases of emergency.

2. These recommendations are made for the following reasons:

(*a*) Ophthalmic surgeons attached to mobile and evacuation hospitals have as a rule no continuous work in their specialty and are frequently assigned duty as ward surgeons, sanitary officers, mess officers, etc., in addition to their eye work, and when an eye case is sent to the operating room work is delayed while the ophthalmic surgeon is hunted up and prepares his instruments and himself for the operation.

(*b*) The ophthalmic surgeon in evacuation and mobile hospitals under the present arrangement is a supernumerary, he having no operating-table assistant, nurse, or orderly assigned him, and interferes with the routine whenever an eye operation is necessary.

3. An arrangement such as suggested above would also release one additional medical officer for other duties.

Before the arrival of a large number of American troops in France a most helpful and important stimulation toward an improvement in the ophthalmic service in the American Expeditionary Forces came about through the observation visit to France and England of several officers from the Office of the Surgeon General.[2] The encouragement given to the young men and the recommendations to the chief surgeon and the Surgeon General as a result of this visit were the real start of the ophthalmic service of the American Expeditionary Forces. Portions of the report on this tour of observation, with the recommendations made, follow:[3]

In accordance with Confidential Order No. 92, paragraph 10, Medical Department, several officers connected with the section of the surgery of the head in the Surgeon General's Office left the United States October 29, 1917, for two months' temporary duty overseas and returned to America March 1, 1918.

One purpose of the trip was to observe the methods employed by the English and French Medical Corps with special reference to ophthalmology.

The method of obtaining the desired information was to visit certain hospitals in an English sector, a French sector, one United States naval hospital, two American Red Cross hospitals, and eight American base hospital units, all of which were in France, and a number of hospitals in London and near London.

The commanding officers of all the hospitals visited, especially the commanding officers of the American units working with the British, and those of the American base hospitals, were talked with freely as to their views on the best method of utilizing the specialities. It was soon found that the general question of hospital organization had to be discussed. Therefore, in the report which follows considerable space is given to this subject.

Every facility was given the observers to obtain the information which they sought. The chief surgeon in the midst of the most pressing duties took time to arrange many visits to English and French hospitals. The staffs of these hospitals went to great pains to get the party where it wished to go, even to the extent of furnishing interpreters and automobiles, and were unflagging in their efforts to furnish details of medical work.

OBSERVATIONS OF THE BRITISH EYE SERVICE IN FRANCE.

The eye work may be classed under two headings; that at the front, and that at the base, and in both situations an attempt is made to group eye cases and handle them in so-called eye centers. It should be stated here that eye centers increased in number and size as the need became apparent; therefore, they vary considerably in their housing, equipment, and force.

Eye centers at the front.—There are five eye centers, one for each army, usually handled by one ophthalmologist, but where the work is heavy there may be two. They are housed in regular army huts, divided up as to the interior plan to suit the convenience of the ophthalmologist in charge. It should be said here that the eye centers are not hospitals by themselves but a department of a casualty clearing station at the front, and of a general hospital at the base. Beside the ophthalmologist in charge, there are a nurse, one or more orderlies, and an enlisted man who has had some previous experience as an optician.

An eye hut is 20 by 60 feet in size, and extensible. It is partitioned off to provide room for the registration examination (including refraction) and treatment of out-patients, a small optical department where glasses are supplied within a very few minutes to those needing them, a dark room supplied either with electric light or with an oil lamp for retinoscopy, and ophthalmoscopic examination, a room for the nurse and a small waiting room for officers. In the rear there is a 12-bed ward and beyond this there is a small space partitioned off as a dressing room for the overflow cases, which are accommodated in one or more marquee tents in the immediate vicinity.

Of the out-patients (usually 20 to 30 a day at a particular center) perhaps one-half are refraction cases. These are examined immediately, receive glasses when necessary, and are sent back to their units. In the same way, mild injuries, such as foreign bodies in the cornea, cases of conjunctivitis and the like, are examined and prescribed for and, if fit for duty, are returned to the line. Cases requiring a few days' hospital treatment are kept and certain emergency operative cases, in which delay might mean serious detriment to the patient, are handled. Serious cases likely to be laid up for a considerable length of time are sent down to the base after being seen by the ophthalmologist. Beside attending the cases referred to the eye center, the ophthalmologist is called to see cases at the other casualty clearing stations in the same army area. These cases nearly all have injuries or disease in addition to the eye condition for which they are being treated. Transportation is furnished for visiting these other stations.

The equipment is that found in an ordinary small eye clinic and is sufficient for all ordinary work. The optician has a fair assortment of lenses and frames with the necessary instruments for mounting them. Eye centers at the front were not equipped with a large magnet for removing foreign bodies from the interior of the eye, but a plan is on foot, and probably is now in operation, to remedy this deficiency.

Serious cases of injury or disease are sent from the casualty clearing stations to the eye centers at the base. An attempt is made to mark these cases with a special tag, orange in color, and with "Ophthalmic" printed on it in black. By so marking cases they can be more easily referred to the special clinics.

Eye centers at the base.—Like the eye centers at the front, these are departments of established hospitals. There are six of them, of which the three most important are: Boulogne, 132 beds;

Étaples, rather smaller; and Rouen with 140 beds. There are 40 beds at Calais, while Le Tréport and Le Havre are smaller and do most of their work among the forces stationed in their vicinity.

The most important eye base is Boulogne, and it was here that the organized eye work in France started in one room, 8 by 20 feet, in 1914. Now there are 132 beds, 12 of which are for officers, and a special out-patient clinic which handles 70 to 80 cases a day, with an optical department which furnishes 200 to 300 pairs of glasses per month. There is also a special operating theater. The patients here are housed in huts which do not differ from the regular army hut wards.

The out-patient department is in a special hut and consists of a waiting room, shared by another clinic, and a clinic room about 22 by 18 feet in size. There is also a small room adjoining for the optical department.

The clinic room is used for the registration of patients and for all forms of examination. There are dark rooms for ophthalmoscopic examination and for retinoscopic examination in refraction cases. Test types are hung across the room high up. A very good electric fixture is installed in the dark room, and refraction is done without having to move the patient. Four good sets of trial lenses are furnished, together with the necessary test types. A trained optician is in charge of the optical department and a large stock of lenses and frames is carried which, within certain limitations, allows the patient to have his prescription for glasses filled within 15 minutes after it is presented. Men in service are allowed two pairs of glasses free; they are usually given one and may send back for a second pair if the first becomes damaged. A stock of artificial eyes is also kept. A special form is made out in duplicate when a patient is furnished with glasses, one copy of which is sent to the army spectacle depot, London, and one copy is retained at the ophthalmic center which furnishes all the data required when replacement is necessary. In addition to this, a record of the patient's vision and glasses on the prescribed form is pasted in his pay book. A card system is in use for making a record of the condition of each patient's eyes. The method of making records, however, varies somewhat at the different centers.

As was indicated before in the case of the eye centers at the front, the ophthalmologist in charge is on call by the various hospitals in the vicinity; this is also the case in the eye centers at the base. There are, however, a number of hospital groups situated at some distance from the eye centers, and in such cases it is the policy when possible to station an ophthalmologist in each one of these, who looks after all the cases in his vicinity.

The question of giant magnets for the purpose of removing foreign bodies within the eye is an important one. A very large number of such cases have occurred in this war. The exact number of cases in which a magnet is useful at Boulogne can not be ascertained, but in a general way it may be said that 4 or 5 cases are put up to the magnet each day and it has been used on as many as 15 in a single day. This does not mean that all these cases have foreign bodies in the eye, but that the eye is sufficiently suspicious to render the magnet test desirable. The magnet test is the simplest and most efficient one for the detection of a magnetic body in the eye, and the magnet is essential for its removal. Giant magnets form part of the equipment only at Boulogne, Étaples, and Rouen, and there is considerable need for them elsewhere. They are, however, bulky, very heavy, and expensive. An attempt has been made by the British to meet this need by the provision of a so-called mobile magnet—a giant magnet mounted in a special ambulance and taking its current from the engine of the car. This has not entirely solved the problem on account of the long distances the car may have to travel and its great weight, which makes it unsuited for poor roads. A small but very powerful magnet, brought over in the equipment of a United States base hospital, 15 inches long, weighing 30 pounds, and costing in the neighborhood of $70, suggested to a British colonel the possibility of equipping more of his stations with magnet facilities, and it is altogether probable that this will eventually be put through, since the need is felt. The varying types of electric current found at different hospitals present, however, a difficult problem, though one that can be solved.

The Boulogne base has the entire or partial service of from four to six men. Two of these, however, do a certain amount of general surgical work in addition to caring for eye cases. It is designed to have three men at Étaples, two or three at Rouen, and one at each of the other bases. A certain number of additional ophthalmologists are necessary to examine and treat the eyes of various groups of alien laborers that are employed by the British. It has been shown that 80 or 90 per cent of the cases referred to the Boulogne base for examination of vision are returned to their units fit for work.

Of 547 cases referred for the vision testing during a period of 3 months, 137 returned fit without glasses, 347 returned fit with glasses, 63 were not helped by glasses and were unfit.

Cases are held at the base a varying length of time according to the amount of activity up the line and the number coming down. Cases not likely to be fit for duty within a month are usually shipped to England, and in time of stress patients may be shipped even after a few days. Operations requiring a considerable period of convalescence, like cataract extraction, are not done in France. After the removal of an eye the patient is usually sent to England, though not always. One-eyed men are useful at the base in France. Of the disposition of the cases shipped to England I can not speak from personal knowledge. Many one-eyed men are referred to the eye wards of the general military hospitals, and there are special institutions in England and Scotland for the education of the blind.

NOTE.—It should be clearly understood that the beds for eye cases provided at the centers do not by any means represent the number of cases that must be cared for. A considerable number of other injuries are always to be found scattered through the general wards Each hospital has its quota. For instance, one hospital has a ward of 38 beds set aside for eye cases, and there is an average of from 20 to 40 cases in the hospital constantly.

Eye service at Rouen.—Rouen is an eye center. The eye hospital in part is in huts, and for extension purposes utilizes marquee tents. It commands about 160 beds and takes cases of the eye from the entire area, approximating 15,000 to 20,000 beds. The arrangement of beds, optical shops, operating theater, etc., are those which have been described and are entirely satisfactory. One is struck by the simplicity of the appointments and their perfection. The out-patient department, equipped as already described, supplies both cylinders and sphericals, which are mounted in round-rimmed frames. Cylinders as low as 0.50 D and up to 6 D are furnished, but sphericals lower than 1 D are usually not ordered, except in case of myopia, when lower combinations are furnished, e. g., −50 −50 axis 180.

All corrections are made with the aid of H and C* mydriasis, and glasses are ordered only after mydriasis has subsided. From 15 to 20 refractive cases are handled each morning, and all the ambulant cases, for example, conjunctivitis and blepharitis (which give much trouble and furnish many cases), small corneal ulcers, lacrymal obstructions, etc. The Haab giant magnet is used with a controller to regulate the current, and all suspected cases are "put up" to the magnet. The magnet extractions vary in number according to the activity at the front, generally from six to eight a week. The anterior chamber route is practically universally employed, exceptions being in the case of large foreign bodies and those easily accessible through the wound of entrance. There are many enucleations and apparently always simple enucleations, implantations, if done at all, being the exception. Glass eyes are furnished.

Eye service at Boulogne.—The arrangements perfected, as before described, are entirely satisfactory. About 140 beds in the best constructed huts are available, but these can be expanded. They take eye cases from this region, one of about 25,000 beds in the general hospital area, in conjunction with a large out-patient service, where 60 to 100 new cases are examined daily, as described in the general review.

Large numbers of patients from the working personnel are examined here, and they, as well as enlisted men, are recorded in four classes, a, b, c, and d, according to the ocular conditions. The magnet work here is very large and has reached as high as 52 magnet operations in one month, 30 a month not being an unusual number; almost always the eye patients have other injuries. All suspected cases are "put up" to the magnet. The anterior chamber route is invariable, and the officer in charge highly disapproved of a scleral extraction.

In the out-patient department some trachoma is noted, chiefly among coolie laborers; other cases are found in inspecting tours.

Eye service in Étaples.—Here the eye hospitals—it being an eye center—are unusually well arranged and comfortable. There are about 120 beds, but these can be expanded to any number required. The arrangements do not differ in any particular from those already described. The Mellinger magnet is employed and is preferred to the Haab magnet. There is a large out-patient department, often 100 cases a day, and many refraction cases.

Summary.—In the British service it is evident that one capable ophthalmic surgeon can in ordinary times take care of the eye cases of about five general hospitals, aggregating a capacity of from 1,500 to 2,000 beds exclusive of the refractive cases applying at the out-patient departments. In times of stress probably two surgeons would be needed. Six eye centers, the more important ones being Boulogne, Étaples, and Rouen, and the smaller ones at Calais, Le Havre and Le Tréport,

* Homatropine and cocaine.

command hospital facilities for eye patients aggregating about 500 beds, which number of beds is amply sufficient for the hospital area, which aggregates something like 50,000 beds. In these six eye centers there are about fifteen ophthalmic surgeons.

The importance of refractive work not only at the eye centers but at the casualty clearing stations is always evident, and the importance of small optical shops and a good supply of cylinder sphericals, easily mounted, in round frames, is also evident.

A giant magnet at such centers is absolutely essential, or if not of the Haab or Mellinger type, then a large Lancaster model. It would seem that a Lancaster model or similar magnet should be placed in those casualty clearing stations where early emergency work is done.

The evidence is overwhelming that the anterior chamber route, with few exceptions, is the operation of choice in magnet extraction.

It is evident that X-ray examination and localization as practiced in the States, except in rare instances, is unnecessary, and in times of stress practically impossible. The important fact is that all suspected cases should be "put up" to the magnet, and that all eyes, even if showing nothing more than moderate congestion, should be treated or tested.

The pain test, i. e., attaching to the magnet a rather long probe-pointed extension and passing this systematically over the sclera, furnishes a test of great value.

The prevalence of blepharitis, of subacute conjunctivitis, probably of the Morax bacillus type, and the great frequency of dendritic ulcers, are rather serious problems. Trachoma, except among laborers, is rare.

Slight contusions, at least those showing only slight external manifestations, are often associated with most serious intraocular changes, and often also associated with marked lowering of the intraocular tension.

Gas conjunctivitis, although very severe, and often showing corneal edema, rarely leads to corneal ulcers; occasionally, however, to sudden corneal disintegration.

The testimony was almost universal that a special hospital devoted to the surgery of the head to include eye, ear, nose, and throat cases, oral and plastic surgery, and neurological surgery, and equipped with dental and optical shops, would be of great advantage. Such hospitals exist, although not always including all these divisions, in the French sectors, while in the English system the special cases are provided for in so-called "centers," i. e., an eye center, jaw center, etc. But by grouping together these departments in one or more of our base groups an increased effectiveness in the surgical staffs and an increased improvement in equipment would be secured, not obtainable if the component parts of such a hospital are placed in widely separated "centers."

A head hospital of this character, equipped with an optical shop and a corps of practical opticians, would solve the question of the supply of spectacle glasses, refractive work, etc.

The establishment of one such hospital in a large hospital area, for example, at Dijon or Chaumont, would provide a most important and useful special hospital, and would not interfere with present arrangements, as described in the paragraph which follows. It would be the center of these types of specialized surgery and afford a place in which eye cases could be maintained until the end of their convalescence—such cases as are not handled in the English centers—but which are evacuated to the various London general hospitals.

It is possible, and even probable, that two types of such hospitals should be maintained, one as near the front as possible to care for the acute and urgent cases, and one at a distant base to care for the chronic cases and those requiring a long convalescence and various types of reconstruction work, especially after extensive injuries to the face, eyelids, jaw, nose, etc.

Only in such a hospital can the best surgical talent of the country along these lines be obtained.

The centralization of these four departments presents evident advantages as compared with the British plans of having individual centers scattered through the base groups in that it would render comparatively easy (*a*) the teamwork of departments which are intimately correlated; (*b*) the minimizing of scattered effort, and would provide at one spot, through its out-patient department in eye, ear, nose, and throat, and dental work, an ambulant service in these regards which experience teaches has been definitely important and which would take care of a large area, again keeping in mind the necessity of correlation among these departments; for example, the same man needing eye, ear, and dental work at the same time; (*c*) the management of patients, especially of those requiring plastic work who of necessity must remain for long periods under observation and treatment; (*d*) the restoration of men to duty on the line or the working personnel is possible

with the other system because of the greater advantage which such concentrated specialized service can render; (*e*) the beginning, should it prove necessary, of the work of reconstruction among those who can not return to duty; (*f*) the development of research work and of a school of instruction in these special departments of surgery.

To meet the requirements of active warfare, eye work can be organized in one of two ways, including that at the front and that at the base:

(*a*) With each army there should be one ophthalmic surgeon stationed at an evacuation hospital (C. C. S.) and associated with him an enlisted man with experience as a practical optician, and also a nurse. This is the English plan of dealing with the ophthalmic problem at the front.

(*b*) At a given number of base hospitals there may be eye departments of the established hospital just as there are other departments of special surgery and medicine, each such center or department to consist of wards of sufficient size for enlisted men and smaller wards for officers, and include an optical shop stocked with spherocylinders adjustable in round frames, in the charge of a practical optician, which shop is part of an out-patient department that takes care of the ambulant cases of the region.

This is the English plan, and at present in the British Expeditionary Forces there are about seven such centers, as they are called.

Experience teaches that for a region containing 10,000 to 15,000 hospital beds, an eye department or center of this character which commands about 150 beds, and which can be expanded by marquee tents for acute cases in time of stress, e. g., a sudden influx of gas conjunctivitis, is sufficient. Two ophthalmic surgeons and one junior assistant are quite sufficient for such a center.

In our base-hospital groups, such groups to be composed, for example, of 10 base hospitals of 1,000 beds each, the plan contemplated by the American Expeditionary Forces, a special department for eye work as described in paragraph (*b*) would meet the situation.

As each of the now actively operating and established American base hospital units has an ophthalmic surgeon and an otolaryngologist as part of its surgical and medical personnel, it is evident that no adequate reason can be advanced to disturb the present arrangements, but it is further evident that (*a*) the equipment of these services, at present quite inadequate, should be brought up to the standard equipment authorized by the Surgeon General's Office and carefully listed there; (*b*) separate bed spaces for eye, ear, nose, and throat cases and rooms for out-patient service, so universally demonstrated by the experience of the English and French medical service as essential, should be provided; (*c*) a small optical shop as before described should be established.

Research work.—The eye surgeons and ophthalmologists at present on duty in the various American base hospitals should be required to expand their duties beyond the mere details of clinical work along the lines of investigation.

Even in the absence at present of patients coming from an active front, but with the patients now in these hospitals and constantly coming to them, there is much to be done which would add an important chapter to the medical history of the war: For example (1) investigation of the ocular complications in mumps cases, which have come in such large numbers to all of these hospitals; (2) investigation of the ocular complications of various infections, particularly those which have attacked the air-sinuses, the lungs, etc.; (3) investigation of the various types of ocular malingering and establishing new and better methods for its detection; (4) a systematic ophthalmoscopic examination of each admitted patient, no matter what his disability may be, and adequate record of the findings and a comparison with the results from the pathological standpoint, should any of the cases come to autopsy.

The supply of eye surgeons is adequate, not only from among those who are now in France but from the carefully catalogued lists in the Surgeon General's Office. The need of especially trained young ophthalmic surgeons, just as young general surgeons are being trained, is again emphasized.

General conclusions.—While it is evident that the present facilities for attending to the eye work of the American Expeditionary Forces should the equipment, etc., be improved are sufficient as long as the troops remain in training, it may be reasonably doubted whether the graver work of operating ophthalmology should our troops in large numbers go into action, is at present adequately cared for. The means of improvement in this regard have been pointed out. The exceedingly well equipped and handled eye centers of the British Expeditionary Forces depend in large measure upon the fact that the British Medical Service has a head of its own in the sense of one ophthalmic surgeon of experience who is responsible for the efficiency of the eye work. The same

rule applies with equal force to the American Expeditionary Forces which should be either under the immediate direction of a consultant or assistant director. All of the many problems of supply, organization, personnel, efficiency of work, distribution of work, etc., would thus be promptly solved.

The opinion expressed that the eye work of the American Expeditionary Forces should, through the Chief Surgeon's Office, be thus under the direction of a "consultant" or "assistant director," is one shared alike by all special surgeons interviewed on this subject, and seemed to be the opinion of the director of surgery. Ophthalmology has as definite a right to be under such direction as has, for example, urology or psychiatry, and its establishment would not only elevate the efficiency of the ophthalmic work in France, but would satisfy our civilian population, which has been given to understand that the National Army, when it goes into action, shall receive the advantages of specialized medicine and surgery in a manner, as far as military conditions will permit, approximating that which the civil population enjoys.

EYE SERVICE IN AMERICAN BASE HOSPITALS.

Personnel.—Without exception the men at present attached to base hospital units are competent, and could, under direction, be entirely equal to much more advanced eye work than that which has thus far fallen to their share. Two of them are capable of good research work and probably all of them could, after training, take care of such work as will come to these hospitals later in the war.

Equipment.—This was found to be, almost without exception, totally inadequate, usually consisting only of a trial case and a few cards and instruments. In not one of the base hospitals was a complete set of instruments and apparatus found, such as is authorized by the Surgeon General's Office, and which instruments, apparatus, etc., are carefully listed, and certainly in so far as the new use of surgical instruments is concerned, ready for shipment. Not a single magnet of either the giant type or new Lancaster model was found, and in only one unit was there any magnet, and that a small, poor, hand magnet, brought over by the surgeon in charge. Should our troops be called into action, the absence of magnets in our eye service would be a most serious matter. For example, in English eye centers during great activity at the front, often as many as 30 magnet extractions of foreign bodies take place in a single month, and it is common to have three or four patients put up to the magnet in a single day. Even as it is, cases requiring magnet extractions of foreign bodies have come to our units from accidents occurring in neighboring camps, and they could not be handled, but had to be, so it was said in one or two instances, sent to adjacent French hospitals for treatment.

In not a single base hospital was found a perimeter, so necessary for diagnostic purposes and the proper study of patients in the eye and other services, especially those in neurological wards.

Almost without exception a supply of mydriatics, especially homatropine, so needful in refractive work, was totally inadequate.

While in some of the base hospitals a separate room or ward for eye cases is at the disposal of the eye surgeon, this should be universally the case; and one or more of the nursing staff should be detailed for duty to such wards in order to receive instruction in the special technique of eye nursing, which is sure to be most necessary when our troops are engaged at an active front.

The need for an out-patient department for eye work at each of these base hospitals, equipped with cards, trial lenses, dark room for retinoscopy and ophthalmoscopy, is an urgent one. In some of our base hospitals rooms for examination of eye patients are either provided or available, but with perhaps one exception they are inadequate.

To such out-patient rooms a small optical shop should be attached stocked with round ground sphero-cylinders and attended by a practical optician as is the case in the English hospitals. This plan would save much time, as now formulæ for glasses must be sent to Paris or the nearest large town and long waits occur before the glasses are received. With a small supply optical shop, the formulæ can be filled in half an hour after they are ordered. The importance and value of the optical shops is fully demonstrated by the English experience, both at the front and at the base, as is also the value of an out-patient department for eye work, where the many ambulant cases from the neighborhood of each hospital can be taken care of.

Character of work.—At present operative work exists only in minimum degree, and none of the eye surgeons with our units has had any opportunity or need to exercise his functions in this regard.

Their work has been confined largely to refractive work, of which they have found much to do, and to the management of the external diseases of the eye, of which there seems to have been comparatively little. They, the eye surgeons, have very properly helped in the other work in the hospital, sanitation, etc., but even so they have plenty of time to develop their services, and should be not only encouraged to do so, but should be required to add to their duties, and in this respect the following recommendations are made:

(*a*) Systematic complete ocular investigations of all patients in the medical, neurological, and general wards and a careful record of each case examined, such record to be filed with the patient's clinical history, exactly as this is done in all well-regulated civil hospitals.

(*b*) Special ocular examinations of the large number of infections of various types, which have crowded the wards even at the present time.

(*c*) Studies of new methods of investigating ocular malingering, unusual opportunities for which are constantly arising.

(*d*) With the help of the laboratory of each base hospital studies of pathological and bacteriological conditions from the eye standpoint.

The plan, and it is a most estimable one, of sending surgeons and physicians systematically to the French, English and even to the Italian fronts, now in operation at our base hospitals, for two weeks' observation and instruction, should be elaborated so as to make it possible from time to time to include the eye surgeons, and thus afford them opportunity of learning the methods of caring for the eye wounds from warfare; or, if this is not possible, the eye surgeons should be given a chance to visit the English eye centers, for example, at Rouen or Boulogne, or the French eye work, for example, at Epernay. This has been done in two instances only, but with great satisfaction and profit.

With no desire to exaggerate the need of skilled eye service in the present war, the whole experience of the English and French shows the paramount need of such service, and our eye surgeons now on duty in our base hospitals should have the opportunity to fit themselves in the manner described for work which is sure to fall to their share. It is proper to point out that at present there are at least three of our eye surgeons serving in British service who have had great opportunities to fit themselves for all kinds of war ophthalmic surgery, who are unusually competent, and it would seem, should be recalled to our service when our activities at the front begin.

The English plan of detailing an eye surgeon of known ability and experience to supervise, as consultant or director, the eye service of the entire Expeditionary Force, should be adopted. The plan, whereby the work of the various eye departments of base hospitals, or centers as the English call them, is correlated and efficiently maintained at the highest standard has achieved most admirable results, and if introduced into our medical system would achieve equally admirable results.

Problems which call for immediate attention.—As our troops are now going into actual warfare it would seem that the following recommendations concerning eye work in France should receive immediate attention:

1. A standard eye equipment in all existing base hospitals, as is already planned.
2. The establishment of one chief eye center, in the sense of a hospital devoted to the surgery of the head, to include eye, ear, nose, and throat and dental work, an optical shop, oral and plastic surgery, and neurological surgery.
3. The appointment of a director, assistant director, or consultant in charge of the ophthalmology of the A. E. F., who shall be required to oversee this work in the various ophthalmic departments.

This very comprehensive report, with its many helpful suggestions and recommendations, was of great value in the subsequent organization of the ophthalmic service of the American Expeditionary Forces. Soon after the return to America of the officer who made the report, base hospitals began to embark for France, each with an ophthalmic surgeon as a member of its personnel and each carrying much of the needed equipment for the eye service. As they arrived in France and were assigned to hospital buildings each ophthalmic officer at once took steps to acquire a room or rooms for his eye clinic and

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was assigned beds for his cases. Figures 1 to 7 give a very good idea of some of the clinic rooms and eye wards that were arranged in various base hospitals.

About two months after this report was submitted an officer, experienced in ophthalmic surgery and having had considerable experience in military ophthalmic surgery through service with the British, was designated as senior consultant in ophthalmology and assigned to the headquarters of the medical and surgical consultants.[4] Later, other consultants were designated and assigned to assist him at headquarters. Through their efforts an efficient eye service was organized, so that at the time of the signing of the armistice there were many large eye centers located where base hospitals were grouped. The isolated base hospitals, evacuation and mobile hospitals, had eye clinics with

FIG. 1.—Photograph of Red Cross military hospital where an eye ward was established and a special operating room arranged for the ophthalmic service.

experienced ophthalmic surgeons in charge. The senior consultant also assigned consultants for the various eye centers and zones, and their duties were outlined by Section I of the following circular issued from the office of the chief surgeon:[5]

I. DUTIES OF PROFESSIONAL CONSULTANTS.

1. The duties of the professional consultants will be to supervise the clinical work of the American Expeditionary Forces. They will be assigned to hospital centers, districts, armies, Army corps and divisions, as the necessity demands, on recommendation of the chief consultant of their respective services, by the proper military authority.

2. In order that the individual consultant may perform his duties effectively, he will make frequent visits to the hospitals or other medical organizations in his territory, as may be required. He shall spend as much time in each hospital, as in his judgment may be necessary, in order to acquaint himself thoroughly with the character and quality of the work done therein.

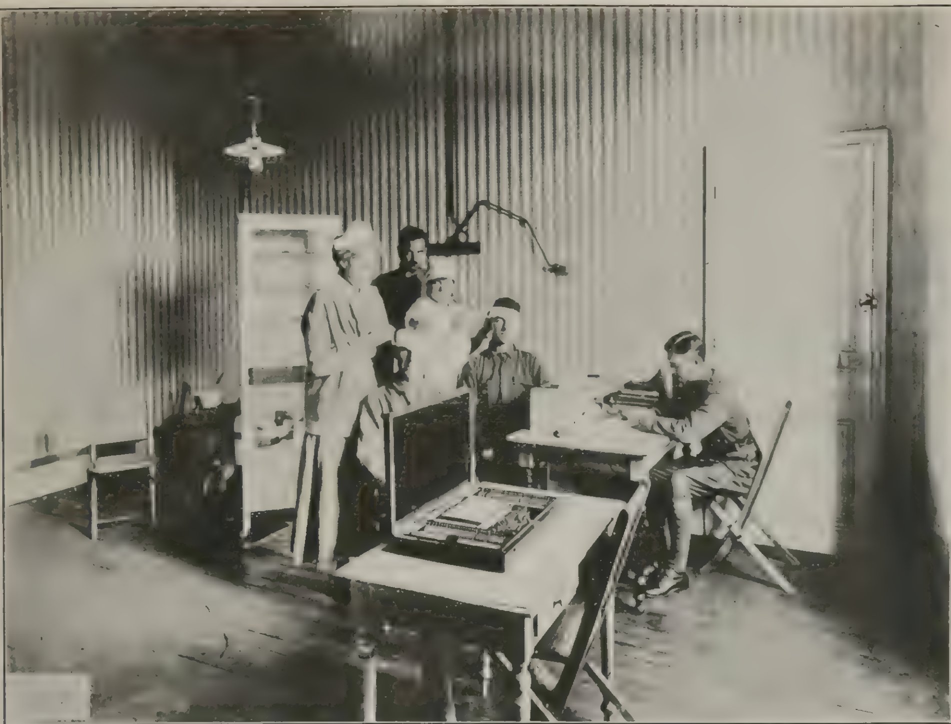

Fig. 2.—Eye examination room, Base Hospital No. 32.

Fig. 3.—Eye clinic, Camp Hospital No. 27.

FIG. 4.—Eye clinic, Base Hospital No. 69.

FIG. 5.—Eye clinic, Base Hospital No. 68.

FIG. 6.—Eye clinic, Camp Hospital No. 9.

FIG. 7.—Eye ward in one of base hospitals.

3. It is the duty of the consultant to supervise the professional work as to his department of the organization or organizations to which he is assigned. He will give advice, instruction, and actual demonstrations as to the best and most efficacious methods of treatment in order that the work of his department may conform to the recognized and accepted standards of the best civil and military practice.

He will make recommendations to the commanding officer as to the ability and professional fitness of individual medical officers of his department. The commanding officer will take the necessary steps to carry the recommendations of the consultant into effect. A copy of the recommendations of the consultant will be forwarded to the senior consultant for his information. In case of difference of opinion between the commanding officer and the consultant, the decision rests with the commanding officer on whom, in all military organizations, the ultimate responsibility rests. This does not interdict the right of appeal of higher military authority.

4. In order that the supervision and direction of the clinical care of the sick and wounded may be consistent throughout, consultants will recommend to commanding officers of hospitals in their respective areas, the names of those suitable for appointments as chiefs of clinical services and specialists in those hospitals.

5. Consultants will render regular monthly reports of their activities. These reports will embody the nature of the clinical work of the organizations in their jurisdiction, the character and quality of the work, and fitness of individual medical officers in their departments. These reports will be submitted to the senior consultant, through the commanding officer of the hospital center, or in base hospitals operating separately the commanding officer of the hospital, or through the surgeon of the unit to which they are assigned.

6. The commanding officers of units in the district assigned to a consultant will afford proper and necessary facilities to the consultant in the performance of his duties.

7. The consultant will report to the commanding officer immediately on his arrival at, and before his departure from, any unit which is within the sphere of this action.

The following extracts relating to ophthalmic conditions are from circulars issued by authority of the chief surgeon, American Expeditionary Forces. The paragraphs quoted were prepared by the chief consultant in ophthalmology:[6]

Circular No. 1.[a]

INJURIES.

Contusions of the eye without rupture. Guarded prognosis, watch tension especially if traumatic cataract develops. Look for and make a record of any choroidal injury.

Contusions of the eye with rupture. If extensive, with great loss of globe contents, enucleate. If less extensive, with little loss of contents, suture and cover with conjunctival flaps after freeing wound of any prolapsed tissue.

Penetrating wounds with foreign body inclusion probable, apply magnet test. If this shows foreign body to be magnetic, remove by magnet, preferably by anterior route if small, and if large through the wound of entrance, if unable to remove small foreign body with the magnet at hand, route case if possible to the base eye center, location of same to be designated later. Where foreign body is nonmagnetic and not easily removable follow expectant treatment as such foreign bodies are often encysted.

It should be especially emphasized that penetration of the eye by a foreign body, without a discoverable wound of entrance, is not an uncommon occurrence. All suspicious eyes should, therefore, be thoroughly investigated for a foreign body, by means of the magnet, the ophthalmoscope, and by X ray when necessary.

Penetrating wounds, without foreign body inclusion should be immediately covered with a conjunctival flap after freely removing prolapsed tissue, then treated as any eye wound. Where an eye is too badly injured to save or where sympathetic ophthalmia is to be feared and no vision likely to result from conservative treatment, the eye should be enucleated. At time of enucleation some material, preferably one of the large glass spheres, should, if possible, be implanted in Tenon's capsule. If this can not be done, it is at least imperative that the four recti muscles should be sutured together.

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[a] The paragraph pertaining to gassed eyes has been given under the heading, "Ophtholmic disturbances due to war gases," p. 714 et seq.

In penetrating injuries of the eye, showing proptosis to a great or less degree, a through-and-through perforation of the globe should be suspected.

Panophthalmitis.—When a penetrating injury results in panophthalmitis it is best to eviscerate and this operation should be the one chosen for a hopelessly injured eye complicated by orbital cellulitis.

After enucleation or evisceration an artificial eye should be fitted as soon as the socket permits.

An only eye or both eyes should never be removed without the advice of the consulting ophthalmic surgeon. The senior consultant in ophthalmology should be notified of any soldier blinded or likely to be blinded as the result of injury or disease.

Orbital injuries.—A small foreign body in the orbit not easily accessible should be left unless cellulitis develops; larger bodies should be removed avoiding injury to muscles and nerves.

Orbital cellulitis requires free drainage.

Perforating wounds of the orbits by bullets or other missiles should be treated symptomatically. Lagophthalmos from the extreme exophthalmos often seen in such cases or the lagophthalmos resulting from facial palsies should have the lids sutured together to protect the eye if there are any signs that the cornea is likely to become involved.

Brain injuries.—All brain injuries or severe cranial wounds likely to show brain involvement should be frequently examined by the ophthalmic surgeons and all opportunities should be improved for studying the fundi and fields of vision of such cases.

TRACHOMA.

The possibilities of the introduction and spread of trachoma among the men of the American Expeditionary Forces requires that every effort be made toward its prevention. Cases of trachoma are bound to be discovered among our troops. Cases showing trachoma in the contagious stages or suspected of being in this stage should be immediately sent to a special base eye center for treatment and cure. Such cases should be segregated at the special center until cured.

Section III does not refer to foreign labor in the employ of the American Expeditionary Forces. Special arrangements will probably be made for handling trachoma occurring in these units.

IV. REFRACTION.

Each hospital in which refraction is done should requisition a sample set of Army spectacle frames from the base optical unit, Army Post Office 702. These frames are numbered 1–2–3. In ordering frames specify the number of frame which fits best, give the interpupillary distance, and in special cases designate the amount of off-set or in-set (this may be read off from the trial frame).

An eye record slip will shortly be issued and is to be filled out for every case refracted. Under sph. cyl. ax., record glasses ordered or if no glasses ordered record error of refraction found. Note whether cycloplegic used and whether glasses were ordered. Other notations explain themselves. This slip should be pasted inside the cover of the pay book, to be issued to troops after October 1, or, if that is unavailable, inside the spectacle case.

It is desirable that a cycloplegic be used as a routine except in such cases as it is unnecessary or contraindicated.

On account of the great scarcity of atropine and homatropine these drugs must be conserved in every possible way. It is suggested that for mydriasis cocaine be used as far as possible and for cycloplegic an oily solution of homatropine one per cent and cocaine two per cent be employed. Instill one drop in each eye and wait 45 to 60 minutes before refracting. By this method a fairly satisfactory cycloplegia can be obtained.

Glasses are only to be ordered when a refractive error exists, which materially interferes with the efficiency of the soldier.

Prescriptions for toric lenses for soldiers and noncommissioned officers will not be filled.

V. RECLASSIFICATION.

Troops will be reclassified as to vision, according to G. O. No. 10, Hq. S. O. S., April 12, 1918. For your information a copy of this order is appended. In interpreting this order a certain amount of latitude is allowed the ophthalmic surgeon to the end that men with useful vision, but not strictly within the above standard, should not be lost to the service.

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The following standards will govern in cases of eye defects:

Class A.—To include men with uncorrected vision 20/40 for the better eye and 20/100 for the poorer one, provided no organic disease exists in either eye.

Class B.—To include cases of toxic amblyopia, active choroiditis, interstitial keratitis, ocular paralysis with diplopia, anterior or posterior synechia, if awaiting operation, and trachoma.

Class C.—To include men with uncorrected vision of less than 20/40 and 20/100 and men with a correct vision of 20/70 in one eye and the other being amblyopic or blind.

Class D.—To include men with corrected vision of 15/200 or less in each eye; men blind in one eye with corrected vision in the other of 20/70 or less; men with glaucoma, retinitis, pigmentosa, optic nerve atrophy, high myopia with extensive fundus changes and disseminated choroiditis.[a]

VI. RECORDS.

For the purpose of later investigation, it is requested that you keep in your department a record of the name, number, organization, and home address of those patients in whom the diagnosis of an intraocular foreign body has been made. This is not meant to include cases in which the eye has been removed.

It is also requested that you keep a careful record of all gas cases developing a definite corneal ulceration, as well as of other cases of special interest.

VII. PATHOLOGICAL MATERIAL.

Enucleated eyes or other pathological material which require examination by a specially trained pathologist should be placed in 10 per cent formalin solution and held pending directions for forwarding. These specimens should be labeled with the name and number of the cases and essential notes of the clinical condition.

VIII. PTERIGIUM.

Pterigium should not be operated on in France unless seriously interfering with the efficiency of the individual.

IX. STRABISMUS.

Strabismus cases should only be operated under exceptional circumstances.

CIRCULAR No. 2.

I. GLASSES FOR THE AMERICAN EXPEDITIONARY FORCES.

Ophthalmic surgeons in the American Expeditionary Forces are requested to exercise great care in prescribing weak lenses. Many prescriptions have been sent to the optical units for simple 0.25 cylinders.

Men who are not doing confining clerical work rarely, if ever, need a glass of this strength. It is also very seldom that 0.50 cylinders are needed unless the axes are oblique or against the rule. Because a soldier is sent down for an examination of his eyes and a weak error of refraction is found, it must not be considered necessary on this account that glasses be ordered when some good advice regarding the care of the eyes will probably accomplish the desired result. No hard and fast rules can be laid down, and ophthalmic surgeons must use their judgment but also keep in view the matter of not burdening the optical units.

II. SIGNING PRESCRIPTIONS.

Ophthalmic surgeons must sign all prescriptions for glasses. All orders for supplies sent to the base optical unit must be in duplicate and sent through the commanding officer.

III. ADJUSTING OPTICIAN.

It is suggested that the ophthalmic surgeons make inquiry through proper authorities in the hospital where they are on service to see if among the hospital enlisted personnel a good adjusting optician may be found who might be available for service in the eye clinic.

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[a] The above classifications refer to the duties for which men were considered available. Class A included men physically fit for combat service; class B included those temporarily unfit for combat service but fit for other duties and who would probably return to class A within six months; class C referred to those permanently unfit for combat service but whose disabilities were not of such a nature as to justify their return to the United States; class D includes those unfit for any duty with the American Expeditionary Forces and who should be transferred to the United States.

IV. WOUNDS OF THE EYELIDS AND ADJACENT PARTS.

Extensive débridement of wounds of the eyelid and adjacent structures is seldom necessary, it being of greatest importance for the proper function of the eye that every effort be made to save tissue in wounds involving the lids and adjacent structures. Primary repair of almost all of these wounds should be attempted and this will alleviate the necessity of much secondary plastic work. In very extensive wounds it may be necessary to insert a small drain in one corner. Special attention is called to the necessity of early and accurate repair of wounds of the lower lid with special reference to those involving the inner portion.

V. ORBITAL WOUNDS.

Orbital tissues should be conserved in doing enucleations and eviscerations. An orbit should never be packed, but where orbital cellulitis exists a small drain is often advisable. An evisceration leaves a very good stump and this operation should be the one selected for a ruptured and collapsed eyeball and for panophthalmitis. It should be the operation of choice where a good clean enucleation with implantation of glass ball is not practicable. Glass balls may be obtained on requisition from the Inter. Med. Supply Depot No. 3.

Circular No. 3.

1. ARTIFICIAL EYES.

Four centers have been established where men requiring artificial eyes can best have them fitted—Base Hospital No. 6 at Bordeaux; Base Optical Unit, Medical Department, Repair Shop, Paris; Base Hospital No. 8 at Savenay; and Base Hospital No. 65 near Brest.

Cases requiring plastics on the eyelids or orbit prior to the fitting of an artificial eye should be routed to Base Hospital No. 115, if practicable. Such cases appearing in Paris may be sent to A. R. C. M. H. No. 1 or 2.

2. TRACHOMA.

Cases of trachoma which occur among the troops can be treated in the base hospitals, but precautions should be taken to prevent any danger of spread of the disease. Special care of towels and handkerchiefs is most necessary. Severe cases likely to require long treatment with resulting impairment of vision should be classified "D" and routed accordingly.

3. TECHNIQUE OF GLASS SPHERE IMPLANTATION IN TENON'S CAPSULE.

(Frost's operation.)

These suggestions are intended for surgeons who have not been accustomed frequently to perform this operation:

(*a*) The eye should be enucleated in the ordinary manner except that the four recti muscles should be isolated and secured separately, either with a small artery clamp or with a stitch, and should be laid back out of the field of operation. The cavity should then be packed until dry.

(*b*) The edges of Tenon's capsule should now be seized at four points with artery clamps and a glass ball, 18 or 20 mm. in size, should be inserted.

(*c*) Silk of sufficient strength is used throughout for suture material. Tenon's capsule is closed with three or four sutures placed in a horizontal line. The muscles are next sutured, superior rectus to inferior, external to internal. The conjunctiva is now closed with three or four sutures in the horizontal line.

(*d*) Extrusion of the glass ball will not occur, except under extraordinary conditions; unless a definite infection of the socket exists a certain amount of reaction is practically always to be expected following the operation. The conjunctival sutures should be removed when the reaction subsides.

4. PLASTIC WORK UPON THE EYELIDS.

In many of the cases requiring plastic work on the eyelids the condition is complicated by defects of the orbital margins and of the fleshy and bony structures of the face. Much progress has been made during this war in faciomaxillary surgery. Our mutilated soldiers are entitled to the best professional advice obtainable and in few cases of this nature is a delay of one or two weeks of any importance to the patient.

Our larger hospital centers, such as Base Hospital No. 115, at Vichy, are especially equipped for this reconstructive work. These cases need special study and often tax the ingenuity and skill of the best trained man. If you are not well equipped to handle this work and if you have not the opportunity to obtain the cooperation of an experienced faciomaxillary surgeon, do not operate, but send the case on to a center where this combination is available.

5. REFRACTION.

Read Circular No. 1 in regard to eye record slips. These slips should now be available in every clinic. They should be filled out in all instances in the clinic where refraction is done. All spaces should be filled in and a note made as to whether a cycloplegic has been used. The slip should then be pasted inside the cover of the pay book which has been issued to each enlisted man. If the enlisted man does not have his pay book with him he should be required to bring it.

6. PERIMETERS.

Hand perimeters can be obtained from Inter. Med. Sup. Depot No. 3. A. E. F., A. P. O. 7375, France.

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CHAPTER I.

INJURIES AND DISEASES.

EYELIDS.

Before the importance of having an ophthalmic surgeon care for wounds of the eyelids and surrounding parts had been recognized many men thus injured had received treatment by the ordinary débridement methods which were being followed in other body wounds, with the consequent sacrifice of much healthy tissue. Later, with more ophthalmic surgeons to care for the work, the treatment of this class of injuries was placed on a more scientific basis. It had been determined, early in the war, that the skin of the lids and face was very resistent to infection, that primary suturing often yielded good results, and that much apparently lifeless tissue had portions to which circulation subsequently returned with marked lessening of the expected deformity.

A number of cases were seen early where both lids had been badly cut and the eye destroyed, for which an enucleation had been performed by removing the remains of the eye, including a good share of the conjunctiva, with no attempt to repair the lid injuries. Healing by granulation had taken place and the patient had to look forward to a long series of plastic operations, which could easily have been avoided by the early suturing of the lids and the conservation of the conjunctiva.

Ophthalmic surgeons were always provided with fine needles, and, with their special equipment of instruments and knowledge of lid anatomy, were better fitted to handle these cases than were general surgeons, it being difficult to make a neat and careful readjustment of the cut conjunctiva with the coarser instruments ordinarily used by the latter. Special care was necessary with tears and wounds of the lids, particularly of the lower lids, which involved the inner angle. This was the most common seat of tears, and any lack of reapposition of the tissue was sure to result in an unsightly deformity, the complete removal of which by later plastic operations was exceedingly difficult. Such a careful reapposition of lid wounds was just as important where destruction of the eye was included in the injury, in order that the patient, with an enucleation or evisceration of the injured eye, might also have a good socket.

It was readily appreciated that the most careful suturing of the conjunctiva must precede or go hand in hand with the suturing of the skin surfaces. Small tags of tissue, which were palpably entirely devitalized, could be removed, of course, but it was astonishing how little of such tissue was found even after extensive shell wounds of the lids.

Cases were occasionally met in which there was entire destruction of one or both lids. In such cases any attempt to do a primary plastic repair was inadvisable, but the tears extending into the surrounding tissues could be carefully brought together to reduce subsequent granulation to as small a region as possible. For suturing cuts and tears of the conjunctiva and of the skin portions of the lids fine silk was used, but for the tears extending into the surrounding skin tissue silk-worm gut was preferred.

The restoration of the line of lashes was best brought about by placing a suture as close to the roots of the lashes as possible, both anteriorly and posteriorly. These two sutures required a very fine curved needle. This also tended to prevent the notching up of the lid margin which was so frequently seen after a cut involving all the layers of the lids, and it was an advantage to include a portion of the cut edge of cartilage in the conjunctival sutures if the cartilage had been cut completely through.

In spite of the most careful early suturing, and especially in consequence of extensive destructions, much plastic work was necessary in the base hospitals back of the zone of advance and in the home hospitals.

The following is an extract from Circular No. 2 which was sent out from the headquarters of the medical and surgical consultants:[1]

Wounds of the eyelids and adjacent parts.—Extensive débridement of wounds of the eyelid and adjacent structures is seldom necessary, it being of the greatest importance for the proper function of the eye that every effort be made to save tissue in wounds involving the lids and adjacent structures. Primary repair of almost all of these wounds should be attempted and this will alleviate the necessity of much secondary plastic work. In very extensive wounds it may be necessary to insert a small drain in one corner. Special attention is called to the necessity of early and accurate repair of wounds of the lower lid with special reference to those involving the inner portion.

CONJUNCTIVA.

The most common form of conjunctivitis was that due to mustard gas, which will be fully considered in the chapter on the ocular disturbances produced by gas. The officer in charge of the ophthalmic service in one of the base hospitals near the front, in reporting on the treatment of eye diseases in his hospital, wrote as follows:[2]

The treatment of "gassed eyes" was the only new feature encountered in the treatment of diseases of the eye. There were 250 such cases admitted to the hospital. They were cared for in the medical wards under the supervision of the eye surgeon. Most of the cases showed a conjunctivitis of more or less severity, accompanied by an intense photophobia and lacrymation. They were treated in the manner advised by the chief consultant, eye section, American Expeditionary Forces, and in every instance made an uneventful recovery. No case developed corneal ulceration. Many of these patients were very uncomfortable for a long time, but all left the hospital in good condition.

One of the ophthalmic consultants personally examined 50 patients as they were brought into a regimental hospital just back of the firing line.[3] Many had just been treated for the first time or were still awaiting treatment. All showed swelling of the lids and intense photophobia and lacrymation. None showed any corneal involvement, but in some cases the conjunctiva was so burned that later corneal involvement seemed likely.

Of the other conjunctival diseases, acute catarrhal conjunctivitis was frequently seen, as well as much chronic conjunctivitis, the eye having been irritated by dust and other substances.

Cuts and tears of the conjunctiva accompanied practically all wounds of the lids and anterior portion of the eyeball, other than those confined to the cornea, while in a few cases the conjunctiva was the only part involved. Small cuts and tears healed readily, but larger ones required suturing, together with the treatment appropriate to the injury which lay beneath the conjunctiva.

Of the chronic diseases of the conjunctiva, trachoma was the one of paramount importance and naturally the cause of some anxiety, in view of the possible spread of the disease, if steps were not taken to prevent it.

Civilian labor was employed to a very considerable extent in France by the French, British, and American forces. In many instances, these laborers were drawn from races in which trachoma is a common disease, and a large number of the individual laborers were themselves infected. The introduction of alien labor companies into France, in some of which trachoma was prevalent, brought a certain amount of danger to the civilian population as well as to the armies.

In July, 1918, the division of ophthalmology of the Medical Department of the American Expeditionary Forces was asked by the medical division of the Labor Bureau to make an inspection of the administrative labor companies, with a view to ascertaining the amount of trachoma existing and to suggest any necessary measures for its control.[4] A conference was held in Paris with the chief of the medical division of the Labor Bureau, who had served with the British Expeditionary Forces, and who was familiar with the British trachoma problem and the way in which it had been handled. It was agreed that our work should be carried out along the same general lines but should be adapted to the special conditions that existed in the American Expeditionary Forces.

There were to be inspected approximately 180 companies, scattered over the whole area of France occupied by the American forces, from the aerodromes close to the front back to Bordeaux and the other base ports. The companies had been taken over from the French, who had organized them, and, at the various centers at which they were gathered together, all had been inspected by the French for contagious eye disease. Racially, they could be divided into Chinese, Indo-Chinese, North Africans, and mixed. The North Africans were composed of several different races—Moroccans, Algerians, Tunisians, and others. Our companies were small, sometimes of not more than 50 men, and never more than 300. They were widely scattered and were engaged on all sorts of projects.[4]

Owing to the pressure of other duties it was impossible to devote a continous period to this survey, and the examinations were spread over a period of four months. The companies in the advance zone were covered by short trips from the medical consultant's headquarters, while those in the intermediate and base sections were examined during a special tour beginning October 10 and ending November 10, 1918.[4]

The work of inspecting the companies in the advance zone began August 7, 1918. In general, the companies were notified several days in advance that an inspection would be made at a certain hour. The hour was chosen so as to interfere as little as possible with the labor of the company. In some cases the companies were examined Saturday afternoon after working hours, and in some cases on Sundays. In certain instances, during the period when the light of the summer season permitted, inspections were held before the men went to work or after returning from work. In the majority of cases the work was done either just before or after the noon meal. There was no uniform schedule of labor for these companies. Some did not work the latter part of Saturday afternoon, and some did not work Sunday, and it was difficult to

hold them for examination outside of their working hours. In all but two instances, inspections were carried out by the officer in direct charge of the work, usually with one assistant, sometimes with more.[4]

The technique of the examination was that used by the British, as follows: The laborers were lined up in three or four files, according to the number of officers making the inspection, and passed before the inspecting officer in single file. Clean cases were immediately dismissed. If a conjunctivitis or trachoma case was detected, the man was detained by a noncommissioned officer, his number ascertained from his identity disk or wristband, and recorded in the appropriate column of the recorder's book. The numbers of those examined were also recorded, so that there was a permanent record of all cases of disease and the men could be sent to their proper companies. One copy of the record was left with the company. Under the system adopted, these examinations were carried out with great speed. Three medical officers would examine 500 men in from 25 to 30 minutes. A copy of each record was sent to the medical division of the Labor Bureau and a copy was filed in the consultant's office. Thus, at the end of the inspection we had a record of all the diseased cases found at the time of the examination.[4]

Cases were classified as Z, or trachoma, only when the diagnosis was evident. All doubtful cases were classed as Y, or conjunctivitis. In the Y class were placed only doubtful cases of trachoma and cases of conjunctivitis with secretion which appeared to be contagious. During the examinations quite a number of cases of old trachoma, noncontagious, with smooth conjunctiva and old scars, were encountered. These were passed as being harmless. The largest number of this group appeared among the North Africans. A number of eye conditions other than conjunctivitis were discovered and their treatment provided for.

Twelve thousand four hundred and sixty-one laborers were examined, and among them were found 1,618 cases of conjunctivitis (13 per cent), and 261 cases of trachoma (2 per cent). By nationalities the results were:[4] Northern Chinese, 4,958 examined; 1,090 with conjunctivitis, 21 per cent; and 160 with trachoma 3.2 per cent. Indo-Chinese, 1,795 examined; 248 cases of conjunctivitis, 16 per cent; and 44 with trachoma, 2.4 per cent. North Africans, 1,291 examined; 51 with conjunctivitis, 4 per cent; and 18 with trachoma, 1.5 per cent. Mixed, 4,417 examined; 193 with conjunctivitis, 4.3 per cent; and 38 with trachoma, 0.9 per cent.

As noted before, the North Africans showed a large percentage of healed trachoma.

Our percentage of trachoma among the northern Chinese (3.2 per cent) was much lower than that found at first by the British (8.5 per cent), but compares well with their examination of later arrivals. This may be accounted for by the fact that a number of our Chinese companies examined had already been gone over and the cases of trachoma weeded out. Several of the companies that had been previously examined, however, showed a number of fresh cases of trachoma and a considerable amount of conjunctivitis. As a rule the trachoma seen among our Chinese was in the early stage. In very few cases was it disabling.

As it was not possible in the beginning to follow the British lead and to establish conjunctivitis and trachoma companies for men with diseased eyes, it was decided to look after them in each company temporarily, as no other course remained open under the circumstances. A circular describing the purpose of the examination was therefore drawn up and sent to every company by the Labor Bureau. The commanders of companies, the medical officers responsible for them, and, when possible, the ophthalmic specialists attached to the nearest hospital were gathered together and the situation was thoroughly discussed and instructions given for the isolation and treatment of the Y and Z groups.

In many instances the companies were in fairly close proximity to a base or camp hospital at which an ophthalmologist was stationed. He was informed of the policy decided on, and the general direction of the eye situation was intrusted to him. Active cases of trachoma were treated by him, as were those of the conjunctivitis group which needed special treatment.

A report was made to the chief surgeon of the American Expeditionary Forces and to the Labor Bureau, giving in detail the figures for the various companies, and the following recommendations were made:[4]

Trachoma cases should be isolated in special companies. These companies should be worked in some hospital area where they can be under the supervision and care of the ophthalmic specialist. The director of the Labor Bureau has already ordered the formation of a trachoma company at a hospital center. Until these trachoma or Z cases would be transferred to such a company, instructions were given to include them with the Y or conjunctivitis cases.

Conjunctivitis cases (Y) should also be put in special companies and given appropriate treatment. Until this can be carried out the following course should be adopted, and the commanding officer of all companies have been instructed in the procedure. The men should be isolated in a separate barracks or part of a barracks. They should, as far as possible, wash separately, eat separately, and work separately from the clean men. Their towels should be boiled for 30 minutes twice a week, as should handkerchiefs when in use. Local treatment consists in the administration of zinc sulphate drops (0.3 per cent) twice a day. This treatment may and should be carried out without interfering with labor.

The Y, or conjunctivitis cases, should be examined by an ophthalmic specialist every three weeks. In six weeks it should be possible to tell which of the suspicious cases are in all probability trachoma, and measures taken accordingly. Where trachoma has existed in a company, a certain number of the X, or clean men, will later develop it, and these must be carefully watched for. Unfortunately, labor companies move so frequently that arrangements for the supervision of the Y cases will break down in many instances under this system. If alien labor companies, especially Chinese, are to be employed for any long period of time by the A. E. F. some provision for the formation of Y companies should be made.

Clean (X) companies.—The medical officer in charge of X companies should be on the constant lookout for fresh cases of eye disease. If these cases do not respond to treatment in a short period of time, the advice of the nearest ophthalmologist should be sought.

It should be remembered, in considering the trachoma problem, that the ordinary methods of handling this disease in civil life did not apply here. We were in France to help win the war, and it was our duty to help the labor authorities to get every possible ounce of work out of the labor companies by every means in our power. The British had shown conclusively that under a well-organized system the disease could be controlled and labor rendered more, rather than less, efficient. Moreover, in the busy times we faced it was impossible to occupy hospital beds with any considerable number of trachoma patients. Rather than do this, it was considered preferable to send the laborers home, but in only a few instances was this necessary.

A comparatively small number of cases of trachoma were found among our soldiers in France, and the proposal was made by the consultant in ophthalmology to the chief surgeon's office that all such cases be segregated in a hospital area where they could be used for light duty. On the ground that there were not enough of them to make this procedure worth while, this suggestion was not acted on, and they were held for treatment in the various hospitals.

The following circular was issued by the Labor Bureau for the instruction of its officers and personnel:[5]

CIRCULAR No. 4.

To Medical Officers assigned to administrative labor companies (through Commanding Officers):

1. A survey is now being made of the Administrative Labor Companies A. S. C., under the direction of the Medical Division, Labor Bureau, by the authority of the Chief Surgeon, A. E. F., as described in Circular No. 2, Medical Division, Labor Bureau, August 7, 1918. The purpose of this survey is to determine the extent of contagious eye diseases with the view of preventing infection and promoting efficiency.

2. Administrative Labor Companies, especially those composed of Chinese and Indo-Chinese, are frequently liable to two contagious eye diseases, conjunctivitis (pink eye), often in its chronic form, and trachoma.

Conjunctivitis is a contagious eye disease which spreads rapidly by contact. It is, however, readily curable under proper treatment, and suitable precautions will limit its spread.

Trachoma is likewise contagious; but, unlike conjunctivitis, it is very resistant to treatment, and in its more severe forms produces irreparable damage to the eyes and may interfere seriously with the efficiency of laborers infected. Certain early cases of trachoma are impossible to distinguish from chronic conjunctivitis until they have been for some time under observation. The spread of trachoma may be checked by suitable measures. Proper treatment will arrest its progress.

Contagion.—Both diseases are conveyed from one individual to another by direct contact with secretion from the affected eyes, by personal contact, by infected towels, and by the use of the same wash basins. Cleanliness is the greatest enemy of these diseases.

Classification.—The present survey will divide the laborers of each company into three classes:

Class X comprises the individuals with clean eyes.

Class Y comprises laborers with conjunctivitis. A few of these may later show trachoma.

Class Z, trachoma cases.

2. As a preventive measure in all labor companies, each man should have his individual towel and soap. Towels should be boiled for 30 minutes twice a week. The same should apply to handkerchiefs.

Class Y should be isolated so far as possible without interfering with their labor. They should live in a separate hut from class X, or, at least, a portion of a hut should be partitioned off for their use. They should wash separately and eat separately from class X, and should work in a squad by themselves as far as possible.

Local treatment of class Y need in no way interfere with their labor. An aqueous solution containing one-third of one per cent zinc sulphate and two per cent boric acid is used.

This treatment is best carried out in the following manner: At a suitable time before going to work and after returning from it, class Y cases report for treatment. They squat down on the ground in one or more lines, pull down their lower lids and look upward. The medical orderly passes along the lines with an assistant. The assistant, who stands behind the laborer, steadies the head with his hands, the medical orderly in front instills with a dropper one or two drops of the zinc sulphate solution which he carries in a small glass. This procedure may be carried out easily without having the dropper come in contact with the eye that is being treated. An orderly may be quickly trained in this work. By this method, up to one hundred cases may be treated in fifteen minutes. After the application of the zinc sulphate, the eyes will smart for from one to five minutes, but not longer.

4. Z cases will be reported by number of the Medical Division, Labor Bureau, A. P. O. 717. Orders will be issued transferring them to special trachoma companies. During the interval between the discovery of trachoma Z cases and their removal, they will be subject to the same precautions and treatment as pertains to class Y. If due precautions, as outlined, are observed, laborers infected with conjunctivitis, X cases, and trachoma Z cases may be handled without danger of infection to other laborers or troops.

CORNEA.

The ever-occurring corneal foreign body offered nothing unusual and yielded to the usual methods for removal. The most troublesome were the multiple foreign bodies produced when sand, gravel, or unburned cordite were driven into the cornea. A great deal of skill and patience was often required to remove these successfully, and frequently an extensive ulceration and subsequent scarring resulted. Abrasions of the cornea were plentiful and for the severe pain and photophobia usually following nothing gave so much relief as the frequent use of 1 per cent holocaine. This was also found to be especially useful for the relief of the pain and photophobia accompanying the exfoliation of the corneal epithelium following severe mustard gas burns of the cornea. Wounds of the cornea not penetrating into the anterior chamber were treated the same as the abrasions.

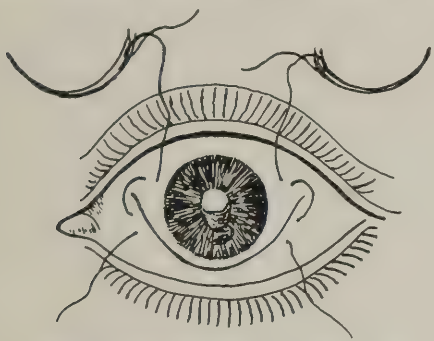


FIG. 8.—Conjunctival flaps. By passing the suture through a fold of the flap and then through a fold above, a firmer hold can be obtained and the anchoring hold should include episcleral tissue.

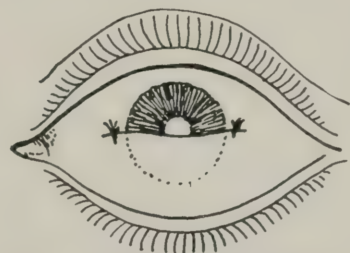


FIG. 9.—Conjunctival flaps—Flap in place.

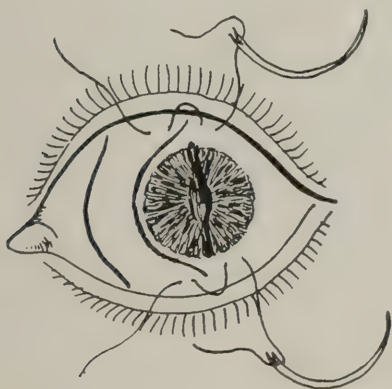


FIG. 10.—Conjunctival flaps—Bridge.

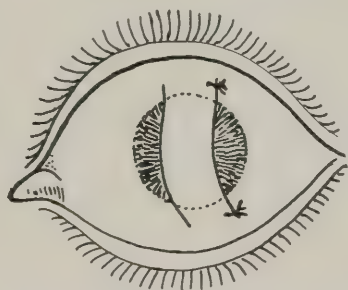


FIG. 11.—Conjunctival flaps—Bridge in place.

Perforating wounds of the cornea, usually required more active interference, owing to the danger of the interior of the eye becoming infected, with the usual accompaniment of iris prolapse, or injury to the iris, lens, or ciliary body. Small perforating wounds, not accompanied by any of the abovementioned complications, usually healed promptly under antiseptic treatment and bandaging. Larger wounds with iris prolapse were well treated by the ophthalmic surgeons of the American Expeditionary Forces, by the use of conjunctival flap coverings and the removal of the prolapsed portion of the iris. The best results were obtained by first fashioning the flap and then teasing out the prolapsed iris until healthy iris had been drawn out, when it was snipped off, followed by the sliding of the conjunctival flap into place. The conjunctival covering usually prevented infection entering the eye and provided a blood supply which aided rapid healing of the corneal tear. The pulling out of the

iris, before cutting it off, prevented anterior synechiæ by reason of the coloboma edges thus produced being away from the wound. Figures 8 to 11 illustrate two methods of making and placing conjunctival flaps.

The varying degrees of keratitis from the most transitory and superficial to the deepest and most destructive, which sometimes resulted from mustard gas, are written of under the paragraphs devoted to the ocular manifestations from exposure to mustard gas. Those forms of keratitis due to tuberculosis and congenital syphilis were rarely seen. The following is a report of a case of neuroparalytic keratitis:

CASE 1.—Pvt. N. K. While advancing to attack on November 2, 1918, the patient was shot in the head. On admission to a mobile hospital some hours later he showed a gunshot wound, penetrating the bone, just outside the outer canthus of the right eyelid. The history as recorded on the field hospital card at the mobile hospital was as follows: "Antitetanic serum was given November 2, 1918. Much retarded mentally. No interference with pupillary reactions. Deep and superficial reflexes, except plantar reflex, present. No Babinski. No paralysis of the extremities. X-ray localization of foreign body within the skull. Position indicated by marks on the skin. November 5, 1918, definite Kernig, stiff neck, somnolence, headache. No Babinsky. Lumbar puncture, blood-tinged fluid, increased pressure. November 11, 1918. Kernig's sign and stiff neck, less marked. Second dose of antitetanic serum given November 4, 1918. No stiff neck and no Kernig. Evacuated.

On admission to base hospital November 17, 1918, findings were as follows: Gunshot wound as described, near outer canthus of right eyelid. Movement of right eyelid normal. Ability to close lid unimpaired. Function of winking normal. Conjunctiva moderately congested. Corneal infiltrate superficial in character occupied center of cornea. No vessels observed in cornea. Its shape was that of an elongated oval with long diameter directed horizontally. The eye seemed strikingly free from the irritation to be expected from such a lesion, lacrymation to any extent being absent. The cornea was found to be completely insensitive. The pupil was somewhat contracted but dilated readily to atropine. No details of the fundus could be observed. Neurological examination was as follows: "Anesthesia to pin over right half of face extending to the median line and outwardly to a vertical dropped from the midtemporal region. Also of the buccal mucous membrane on the right side of and the right half of the tongue. Taste for salt and sweets lost on the right side of the tongue. The patient's memory is not good, but careful questioning establishes that sensory symptoms were not of immediate onset, but have progressed gradually. Taste, he feels sure, was normal hours after the injury and the numbness was very slight in that period. Opinion: Fracture of base involving bony structure about or near the Gasserian ganglion." X-ray report made as follows: "Foreign body noted in the occipital area of the brain." The condition one month later showed no change. The eye was kept bandaged. This had no influence on the cornea. The diagnosis was: Neuroparalytic keratitis, due to trophic disturbance, consequent upon injury to the fifth nerve.

IRIS.

Ruptures of the pupil margin of the iris and the tearing of a sector of the iris from its attachment (iridodialysis) were common following contusions of the globe and presented no unusual problems. Prolapses were dealt with as already described. Attacks of iritis due to syphilis and especially to focal infections were as frequent as might have been expected, but offered nothing especially noteworthy. Iridocyclitis, following perforating injuries, was quite common and, if persistent and occurring in a blind eye, demanded enucleation. Sympathetic uveitis is mentioned in a separate paragraph.

The following case is a good example of average injuries involving the iris:

CASE 2.—E. P. Patient was brought to the hospital with a perforating wound of the right eye caused by an exploding hand grenade. The wound was near the limbus inferiorly and the iris was prolapsed. This was immediately drawn out and excised; a sterile magnet tip was inserted but failed to demonstrate the presence of a magnetizable foreign body. The pillars of the coloboma were replaced and a conjunctival flap brought over the sclerocorneal wound with perfect surgical results.

A. CASE 3. FUNDUS OF RIGHT EYE SHOWING LARGE TEAR THROUGH MACULAR REGION.

B. CASE 4. FUNDUS OF RIGHT EYE SHOWING EXTENSIVE DESTRUCTION IN AND ABOUT MACULAR REGION.

THE LENS.

Many cases of luxation or subluxation of the lens were seen and many of traumatic cataract. Contusions of the eyeball were responsible for most of the former and penetrating wounds for the latter. In the reparative treatment given to perforating corneal wounds with iris prolapse it was often possible, after cutting off the prolapsed iris, to remove the cloudy lens substance of a traumatic cataract. Frequently it was considered wiser to leave the traumatic cataract for later treatment. Many cases of this nature were classified for return to the United States for treatment. Among the blind were 11 patients with traumatic cataracts and it was expected that certain of them would have some return of vision after treatment in hospitals in the homeland.

RETINA AND CHOROID.

A study of battle blind gives a good idea of the frequency of retinal separation and rupture of the choroid mostly due to contusions of the posterior part of the eyeball by missiles passing into or through the orbits or by concussion waves imparted to the orbital contents by destructive blows to the bony framework of the orbits. A chance to study unusual types of choroidal ruptures, retinal separations, and macular holes was afforded to many ophthalmologists. A description of some of these cases is to be found under orbital injuries. The following cases show certain types of choroidal and retinal injuries:

Case 3.—E. B. Gunshot wound on the right side of the face. There was a scar at the outer margins of the orbit extending into the eyebrow and down toward the cheek. This scar had drawn the lower lid out and downward. At the time of injury there was no abrasion of the eyeball, although there was considerable subconjunctival hemorrhage. Following the injury the man noticed he could not see clearly. V. O. D. = fingers at 3 feet. V. O. S.=20/20. The fundus of the right eye showed a large tear extending through the macular region. (Plate I–A)

Case 4.—H. M. C., age 22. Injured by bursting shrapnel. The right eye was slightly lacerated but, after this healed, the vision did not return. Later a small piece of shell was removed from the eye. The right fundus showed an extensive destruction in and about the macular region. (Plate I–B.)

Commotio retinæ and retinal hemorrhage, as well as separation, were often present, following orbital shocks, as shown in the following case reported from one of the forward base hospitals.

Case 5.—Lieut. F. B. S., aged 30, admitted April 22, 1918. Patient was caught in a barrage on April 19, many large shells exploding in his immediate vicinity. Was unconscious for a few minutes, but later discovered that his face had been peppered and was swollen and blue. The vision of both eyes was blurred from the onset. The swelling about the lids and eyes was so great that he could not open them for some time. He was transported to an evacuation hospital and shell splinters were removed from left temple.

Examination.—Entire face peppered with small wounds, gravel, dirt, and tiny shell bits, and, together with the lids, swollen and puffy. The largest of the small superficial face wounds was 1 cm. in diameter, covered with a thick scab, and situated just below the right eye. Both eyes show marked traumatic conjunctivitis and conjunctival ecchymosis. Ophthalmoscopy: Both eyes presented large retinal hemorrhages, commotio retinæ, and numerous small areas of retinal detachment, while blood extravasations into the vitreous were noted in the periphery of the right eye. Advised radiographic studies. April 26, 1918: The patient said his vision was clearing. After rest and indicated treatment an improvement was noted ophthalmoscopically, the retinal edema having subsided, the small circumscribed retinal detachments having become reapplied, and most of the hemorrhages having been absorbed. There remained, however, two large, globular,

black-bordered old blood masses in the extreme infero-nasal periphery of the right fundus. V. O. D.=20/100; V. O. S.=20/50 cycloplegic present. Radiographic report: Small foreign body, the size of a pinhead, situated in the left orbit 12 mm. posterior to the center of the cornea, 16 mm. to the temporal side of the vertical plane, and 16 mm. below the horizontal plane of the cornea. This measurement put the foreign body in the orbit but outside of the globe. Small foreign body in the right eye clinically palpated and found not intraocular. April 30, 1918: The vitreous hemorrhages were rapidly organizing and the vision of the right eye had improved to 20/70. May 2, 1918: Under cocaine anesthesia removed a small, nonmagnetizable foreign body which was imbedded in the sclera of the right eye beneath the belly of the internal rectus muscle. May 4, 1918: V. O. D.=20/50; V. O. S.=20/30. This showed an increase in the visual acuity of each eye. May 22, 1918: Ophthalmoscopy; media clearer and fundus landmarks more visible. Dionin to further aid absorption. May 27, 1918: Vitreous much clearer and fundus details easily studied. V. O. D.+1.25; S=20.30. Discontinued treatment and discharged to duty.

Unfortunately for the patient, but fortunately for our follow-up records, he was again wounded, this time through the neck, shoulder, and abdomen, and was sent from an evacuation hospital on July 11, 1918. As soon as he felt equal to the tests he was given a thorough examination, the fundi were found negative and the vision of each eye, with correction, was 20/20.

Diagnosis: Commotio retinæ, traumatic, bilateral; foreign body left orbit and right sclera; retinal detachments, traumatic, bilateral; hemorrhages, retinal, traumatic, bilateral; hemorrhages, vitreous, traumatic right.

Two types of retinitis were of special interest to the Army ophthalmologists, namely, albuminuric retinitis occurring during the nephritis of scarlet fever, and that occurring during the early stages of trench nephritis. Each was very transitory, and in trench nephritis was not to be seen unless looked for before the patient had begun to improve under treatment. The following is an example of retinitis pigmentosa, of which many were observed:

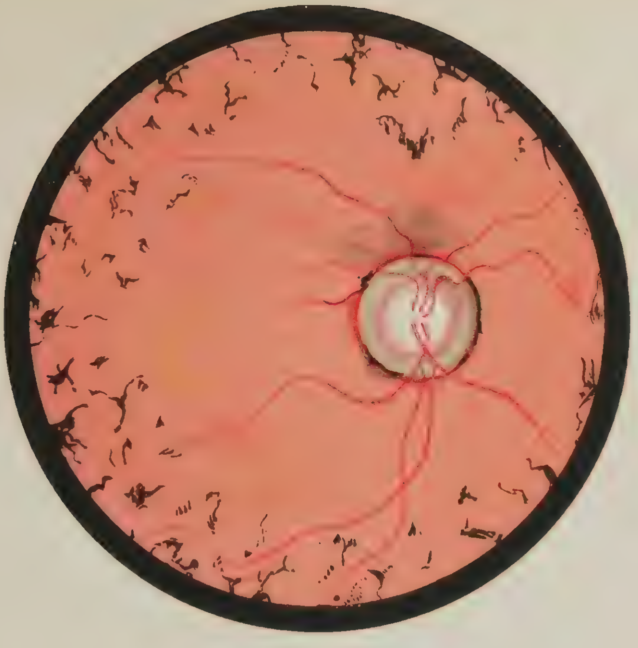
Case 6.—F. J. S., aged 27. (Plate II–A.) Diagnosis: Retinitis pigmentosa. This case is interesting on account of the fact that he had fairly good central vision and for this reason had passed through several examinations. He was finally put on duty in the forward trenches, where it was discovered that he had very poor vision at night; he was, therefore, referred back to the hospital for examination and treatment.

Night-blindness was, of course, the prominent symptom in these cases, but the ophthalmic surgeons of the American Expeditionary Forces were cognizant of the fact that there were numerous cases of night-blindness which had no pathological basis for the symptom. Sometimes the condition was greatly exaggerated, and again it could be accounted for by general bodily exhaustion and nerve strain. The fact that the nights in French towns were made particularly dark, in view of possible air raids, may account for the discovery of early stages of night-blindness.

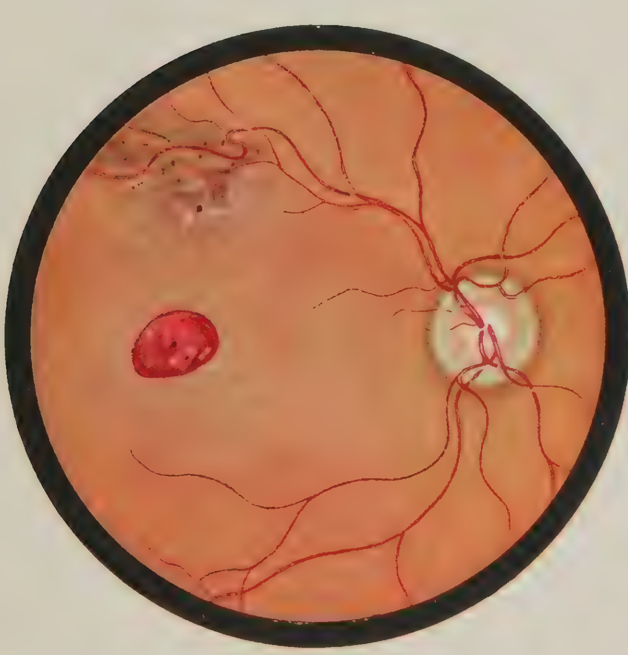
The most striking and unusual form of choroiditis was metastatic choroiditis, which rapidly resulted in a panophthalmitis and which was a manifestation of a septic process elsewhere. The headquarters consultants saw four cases, and in all four the original septic process was connected with a compound fracture of a femur. In one case seen in a hospital near Paris the right femur had been fractured by a shell injury and the thigh was infected with the *B. welchii*. The left eye showed a severe chemosis, with muddy iris and yellowish pupil reflex. No treatment was advised as the patient was evidently about to die

OPTIC NERVE.

The various types of optic neuritis and the various injuries produced by fractures of the orbit, or the passage of pieces of shell or bullets, have been mentioned under other headings.



A. CASE 6. RETINITIS PIGMENTOSA.



B. CASE 8. FUNDUS OF LEFT EYE SHOWING LESIONS IN MACULAR REGION.

A few cases of toxic amblyopia were encountered, and a number of cases of retrobulbar neuritis, due to extension from the nasal cavities.

A very interesting case of retrobulbar neuritis was seen in one of the base hospitals and the following report of the case is presented:

CASE 7. Pvt. J. F. E., aged 19, received at base hospital September 21, 1918, with diagnosis of retrobulbar neuritis, bilateral. Patient had been at front and exposed in trenches most of time for eight months; had had frequent head colds, with pain in the forehead and reduction of vision. For past three months the pain had been more severe and vision further reduced. On admission he had severe bitemporal headaches almost constantly.

Findings: V. O. D.—finger at 1 foot; V. O. S.—motion at 1 foot. Pupil O. D. reacted to light sluggishly and partly. Pupil O. S. was dilated one-third and reacted to light slowly and slightly. No redness of conjunctivæ, cornea clear, lids normal. Discs hazy and raised slightly. Nose: Both nares showed much yellow discharge coming forward and going into pharynx. Transillumination of frontals and antri not positive. Ordered quiet, eliminative treatment, daily nasal lavage and argyrol tampons. Wassermann, blood count, and urinalysis ordered. September 22, 1918: Perimiter showed right field concentrically narrowed, central fault questionable owing to reduced vision. Left field not recordable on account of poor vision. September 27, 1918: Nose much cleaner, headache subsided. Wassermann negative, urine not pathological, blood count showed slight leucocytosis. In right naris a concretion in middle passage, too large to be extracted forward or to be pushed back to pharynx, could be detected. This was imbedded in bleeding and infected granulations, and manipulation caused little discomfort. No history of war wound to explain foreign body, and patient did not recall having placed a foreign body in his nose as a child. X-ray showed all sinuses clear except right antrum. September 30, 1918: Under general anesthesia, the concretion was forced back into the pharynx and extracted. It proved to be an irregular stony mass about 6 by 4 by 2 cm. and when broken it was found to contain an old bone button. The patient again could not recall any previous relations to its placement or presence in the nose. Apparently it had been there a long time. November 9, 1918: Patient in bed with slight temperature because of multiple arthritis apparently from the nasal infection. Had planned to open ethmoids and sphenoids, which continued to drain. Eye-grounds clearing slowly and some improvement in vision. November 20, 1918: Under local anesthesia the ethmoids were opened and found moderately infected, and the sphenoids contained about one drop of pus, with thickened mucosa. Promptly the vision began to clear and general well-being ensued. Patient was lost within a few days by evacuation. About two months later patient was casually seen at camp and he was seeing as formerly, his head was clear, and he was ready for duty. No opportunity was available for examination of the fundi at this time.

Comment: Of interest is the record contained in a letter from his home oculist of one year previous and before enlistment: V. O. D.=20/70+11.00+S 2.00 C ax 105°=20/40. V. O. S.=20/200+11.00+S 2.00 C ax 75°=20/200.

The presence, for a long period, of an irritating foreign body in the nose without manifesting warning symptoms is interesting and must be considered in connection with the nasal infection. However, exposure alone in front line duty under conditions recited in the history was sufficient to cause the rhinitis and sinusitis. In cases showing optic neuritis from nasal sinus empyema, the development of polyarthritis is not common. In this case, the high refractive error, the long time which elapsed, the lesion in the nose without visual changes, and the presence of the nasal foreign body, with a satisfactory recovery, are instructive.

ORBITAL INJURIES.

Injuries to the orbits, and their surroundings, were very frequent and occurred in many degrees and varieties. Penetration and perforation of the orbits by foreign bodies, particularly bits of shrapnel and bullets, were frequently seen.

The majority of the penetrating wounds of the orbit were complicated by the presence in the orbit of the foreign body. Many small bits of shrapnel found their way into the tissues behind or around the eye, where they became encapsulated and gave rise to no serious consequences. So true was this that it was unwise to make any extensive exploration for small foreign bodies located in the orbit. If the foreign substance had carried infection into the orbit, an orbital cellulitis sometimes resulted, which required drainage, and in the process of draining the foreign body was occasionally extruded. The temptation sometimes was great to explore for these small particles, but it was much wiser for the sake of the patient to resist the temptation and not interfere surgically.

In cases where a larger foreign body had penetrated the orbit there was usually such a considerable destruction of tissue that the foreign body could be removed without adding to the already existing trauma. In many cases the foreign body had passed through the globe, tearing it to pieces, and becoming lodged behind the eye. In all such cases a careful X-ray localization was the best procedure in making sure that the bit of shrapnel had not perforated the roof of the orbit and become lodged in the brain, thus putting the case in the class of those requiring the skill of the brain surgeon.

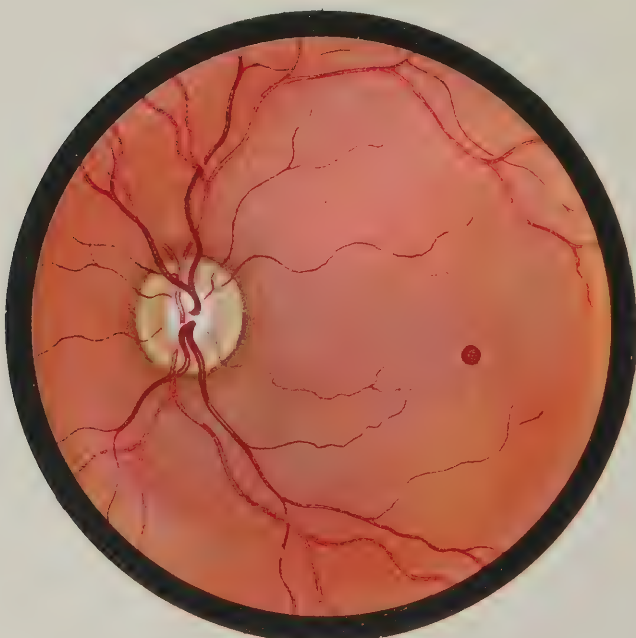
Perhaps the orbital injuries which excited the greatest interest were those occurring in considerable numbers, where the bullet, passing behind the globe or through the bony tissues surrounding it, had produced more or less severe injury to the globe by extension of the trauma, without actually coming into contact with the globe itself. A great many choroidal ruptures, macular holes, hemorrhages, severed optic nerves, and other interesting ocular findings were recorded.

In a considerable proportion of the men who are at present in the class of the battle blind the blindness resulted from the passage of high-velocity bullets through the orbital apices. Very little can be done for this interesting group of orbital injuries. The application of ice compresses often lessened the amount of hemorrhage and the subsequent reaction. Where there was a large clot of blood in the orbital spaces, causing an extrusion of the eye, it was frequently necessary to sew the lids together to protect the cornea from exposure keratitis.

Case 8.—Pvt. D. J., aged 18. In Army one year. Admitted to a base hospital September 13, 1917. Chief complaint, drooping of upper right eyelid, and blindness of the right eye. On August 11 received gunshot wound of head, right frontal region; was unconscious for four hours, after which he was hazy for several hours. At this time he observed that the right eye was swollen and that he could not open it. On raising the lid he noticed that the eye was blind. Six hours after injury he had an operation. Following this he had severe headache for three days. After that had had no trouble except the present eye condition.

Notes from evacuation hospital: Fracture of skull, right frontal, penetrating orbit, with loss of bone substance and orbital fat. Operation: Foreign body removed from orbit, dura exposed, orbit cleaned out, and skin edges sutured. Present findings: Head wound healed; loss of bone substance 3 cm. in diameter up and back from the outer canthus; paralysis of frontalis muscle within scar boundaries, also loss of sensation here. Mental and physical examination otherwise negative. Eye examination: Vision, O. D.=L. P. up and out. Vision, O. S.=20/20. Right eye, complete ptosis, paralysis of superior rectus; external examination otherwise negative. Fundus: Few fine floating vitreous opacities, media otherwise clear; disc round; rings very distinct; cup present and deep; lamina cribosa present; whole disc slightly pale, more marked temporally. Arteries slightly smaller in caliber than normal; reflex stripe present. Veins normal in caliber and regular, except where the superior temporal makes an unusual loop just above the

A. CASE 10. FUNDUS OF RIGHT EYE SHOWING MACULAR HOLE.



B. CASE 11. FUNDUS OF LEFT EYE SHOWING MACULAR HOLE.

macular region. The macular region shows a very interesting oval lesion, long axis 180. This lesion is about two-thirds the size of the disc, with the border distinct and regular. This area appears to be slightly depressed, the lower showing a deeper edge than that above. The lesion is bright red in color; near the lower border there are many small brown pigment spots, and situated in this region are four small glistening spots resembling cholesterin crystals, also a few slightly larger grayish bodies, which are probably hyaline bodies. Extending from this lesion up to the superior temporal vein there can be seen a large number of small, irregular, brownish pigment spots, situated in the retina, under the superior temporal vein. These are most conspicuous, some lying along the wall of this vessel. Near many of these pigment spots there can be seen some shining, veil-like masses which are probably an increase of glial tissue. The area of pigment extending directly up to the temporal vein is about 1 disc diameter broad. The retina elsewhere has a normal appearance. (Plate II–B, facing p. 686.)

CASE 9.—Pvt. M. B. On November 13, 1918, patient was accidentally injured by an exploding shell. Admitted to evacuation hospital on November 8, 1918, and evacuated on November 16, 1918, to a base hospital. On admission to base hospital there was a lacerated gunshot wound of the lower right eyelid at the inner canthus, the lid being completely severed at this point. There was also a penetrating gunshot wound of the right cheek over canine fossa, extending to the ala nasi. The conjunctiva was acutely inflamed. The cornea presented a central abrasion; no details of the fundus could be seen. X-ray examination negative. Vision was reduced to perception of hand movements. The corneal condition gradually improved until, on December 10, 1918, details of the fundus could be seen. Opacities of the vitreous were present, an especially large exudate being observed in the lower inner part of the vitreous. There was a linear rupture in the choroid extending from a point near the inner margin of the disc upward and inward about 2½ papilla diameters. Several areas of choroidal exudate, with pigmentation, were seen. In the macular region there was a circular area about one-third of the disc diameter in width, having sharply defined margins. The center of this area appeared somewhat depressed, in contrast to the clearly cut margins. It was of dark red color and had the appearance of exposed choroid, although no vessels were discernible at the time of observation. Vision at last date of examination, December 22, 1918, ability to count fingers at one-third of a meter.

CASE 10.—R. C., aged 21. On entering the Army he had good vision in both eyes. Nine months previous to examination he was injured by shrapnel at the outer angle of the right eye. He had a large scar beneath the right eye, with considerable contraction that drew the outer canthus somewhat downward. At the time of injury there was no cut or abrasion of the right eye. Vision O. D.=20/200. Vision O. S.=20/20. The right eye was normal in all respects, except for the fundus, which showed an oval depression in the macular region. This depression had markedly sharp borders with a deep reddish base. External to the macula and a little below, there was some retinal degeneration, with slight pigmentation. At the first examination there was small cholesterin crystal on the floor of the macular lesion. Twenty-four hours later this crystal had disappeared. Fields showed no contraction, but there was a central scotoma. Diagnosis: Macular hole. (See Plate III–A.)

CASE 11.—W. B., aged 28. Negro. Two days before entering hospital was struck in the left eye by a baseball. On first examination he complained of pain and loss of vision in the left eye. Vision O. D. 20/40. Vision O. S. 20/200. Fields in the right eye were normal. Fields in the left eye not contracted, but there was central scotoma. Right eye was negative. Left eye showed a slight exopthalmos; slight ptosis. Conjunctiva slightly swollen; subconjunctival hemorrhage. Cornea clear. Iris normal. Pupil double the size of the right, but reacted to light and accommodation. Lens clear. Vitreous slightly cloudy. Fundus showed a reddish patch in the macular region, but the exact nature could not be determined on account of the cloudiness in the vitreous. Five days later the vitreous had sufficiently cleared to show a small, well-defined macular hole. (Plate III–B.)

Direct blows on the eyes frequently caused ruptures of the choroid or retinal separation. The following is an illustrative case:

CASE 12.—Pvt. H. M. C., aged 23, Infantry. February 3, 1918, patient admitted from a camp hospital, with diagnosis on transfer card: "Punctured wound of eye right, suspected; accidentally incurred at maneuvers in France, January 24, when he received a blow from a fragment of hand grenade." When a child he was struck above the right eye, near the bridge of the nose, with a

small birdshot, which still remained subcutaneously and was quite easily palpable. Camp hospital history: "About 19 days ago patient was injured by an exploding hand grenade, a portion of the detonator striking the patient in the right eye, which bled profusely and immediately swelled until the lids were closed. Was treated in the company infirmary until sent here. After the swelling subsided sufficiently to permit of accurate examination, the eye was minutely inspected, but no lesion or point of injury could be found either in the globe proper or anywhere within the conjunctival sac. Some dirt particles were removed, and the eye was noted as being considerably inflamed and painful. The vision of the right eye was reduced to mere light perception, and because this did not improve patient was sent to a base hospital." The following was noted as the result of examination at the base hospital: "The patient was perfectly well except for the injured right eye. The right eye was slightly swollen and the conjunctiva somewhat inflamed. The iris had a muddy look, and there was a circumcorneal injection, while fine, radiating corneal blood vessels were detected. The anterior chamber was deep and tension lowered. Vision was entirely obliterated except for faint perception of light and form in extreme temporal field. The left pupil reacted normally; the right was dilated with atropine. Vision O. S.=20/20." February 4, 1918, ophthalmoscopy: O. D., media turbid, fundus reflex amber colored. Papilla and details of fundus slightly veiled, somewhat hyperemic and edematous. There were areas of pigment deposit in the retina and choroid, while the retina, temporal to the fovea, was slightly edematous. Impression of traumatic uveitis and commotio retinæ. February 10, 1918, ophthalmoscopy, right eye: There were large stationary and floating vitreous opacities, and areas of retinal and choroidal edema and atrophy, while there was a distinct rupture of the choroid in the macular region, with atrophy of the optic papilla and detachment of the retina. Left eye: Negative, save for engorged veins. Wassermann: Previously advised, reported negative. Diagnosis: Commotio retinæ, right eye; rupture of choroid, right eye; detachment of retina, right eye, atrophy of retina and optic nerve, post traumatic.

Fracture through the orbit occasionally caused injury to the optic nerve and descending atrophy. The following cases are illustrative of this:

Case 13.—Pvt. C. R. P., aged 28. September 18, 1918. Was knocked unconscious in an automobile accident nine days ago. Thought the left side of his face was struck by the car because it swelled almost immediately and the vision failed in the left eye at the same time. As the swelling subsided he became aware that he was totally blind in that eye. The pain was very intense at first, being superseded by a headache which lasted four or five days, followed by a feeling, which persisted, as if a tight band was around his temples. Immediately after the accident he bled from the nose and mouth, but after vomiting steadily for about an hour, the bleeding ceased. Patient felt well except for the tightness in the head on coughing, and difficulty in gauging distances, attributable to the blind left eye. Diagnosis on transfer card from a field hospital: "Contused wound of left supraorbital region, moderately severe." Ophthalmoscopy showed atrophy of the left optic papilla, probably due to fracture of orbital wall through optic foramen, with severance or compression of optic nerve. Vision O. D.=20/30. Vision O. S.=total amaurosis. Static refraction: O. D.+.25 S+.25 C ax. 165°=20/20. Opthalmoscopy: Right eye, negative: left eye, pallor and atrophic concavity of the entire nerve head.

Case 14.—Pvt. A. S., aged 25. July 9, 1918. Patient had been shot through face by a machine-gun bullet, which entered at the lower edge of the right nasal sinus, emerging beneath the left zygomatic arch. Vision O. D.=20/20. Vision O. S.=8/200. Ophthalmoscopy: O. D. negative: O. S., media clear, save for a few partially organized floating vitreous hemorrhages. The papilla was paler than normal, the retinal vessels attenuated and apparently decreased in number. A few small scattered areas of retinal detachment and hemorrhages were in the macular region, as well as at the periphery. There were numerous disseminated choroidal hemorrhages and pigment changes; about 1.5 disc diameters supertemporal to the disc there were several typical ruptures of the choroid, the underlying white sclera and the overlying retinal vessels being clearly discerned.

Impressions: In addition to the above-noted intraocular changes, a fracture of the floor of the orbit was suspected, with probable involvement of the optic foramen and a commencing descending optic nerve atrophy, the vision of the left eye having gradually grown worse under observation until the patient was evacuated farther back.

Another case showing an unusual sequela of fracture through or near the orbit is presented from the notes of one of the headquarters consultants:

CASE 15.—Patient, aged 30, was seen in one of the base hospitals, with marked exophthalmos of the left eye and much chemosis, especially below. With the idea that the condition was one of orbital cellulitis, the local surgeon had opened into the orbit, with negative results. The previous history of the case showed that on June 3, 1918, patient had been struck over the right temporal region and rendered unconscious. At one of the evacuation hospitals a fracture of the outer table was found, but, on trephining, no fracture of the inner table. Patient was unconscious for several days and it was noted that he had a right-sided paralysis, from which he had slowly recovered. Ptosis was also noted and some exophthalmos on the left side, all showing that the real vital injury to the skull was by contrecoup on the left side and involving the left orbit. Examination showed a marked proptosis of the left eye, so that the lids did not fully close. There was much chemosis and the cornea was hazy. On attempting to press the eyeball back into a more normal position an immediate pulsation was felt, the rise and fall of the fingers of the examiner could be plainly seen, being synchronous with the pulse beat. This established a diagnosis of pulsating exophthalmos due to the creation of an arteriovenous aneurysm, probably by the penetration of the internal carotid artery and cavernous sinus by a splinter of bone from fracture by a contrecoup. The use of a stethoscope demonstrated a loud bruit over the temporal region. The consultant advised rest in bed, with periods of compressing the left common carotid several times a day to avoid sudden cerebral disturbances if it later became necessary to ligate the left internal carotid. Measures were taken to protect the exposed cornea.

The local surgeon reported as follows: Right eye.—Slight congestion of the superior and inferior palpebral conjunctiva; vision 20/30++; otherwise eye perfectly normal. Left eye, marked evidences of typical pulsating exophthalmos: great engorgement of the palpebral and bulbar conjunctiva; extensive chemosis, particularly inferiorly; lagophthalmos and haziness of the corneal epithelium; definite restriction in the movements of the globe; vision 20/60; pupillary reactions normal. Ophthalmoscopy: Right eye, negative; left eye, retinal veins dark and distended. Disc margins a trifle blurred. Fundus noted as physiological, despite the slight veiling of all details owing to the dryness and haziness of the exposed corneal epithelium. Perimetry, urinalysis, and Wassermann negative. Dental and laryngological consultations fruitless. X-ray: Right frontal bone shows an area of increased radiability due to removal of bone from that area. The frontal, sphenoidal, ethmoidal, and maxillary sinuses are clear. There is no Roentgen evidence of change in the region of the sella. Linear fracture nasal side superior border of left orbit.

August 24, 1918, patient was transferred to a base hospital farther back, where, on September 23, the internal carotid was ligated, with the result that the condition was practically cured, with much improvement of vision.

The following is a report of a case having foreign bodies (penetrating shell fragments) in Tenon's capsule.

CASE 16.—Pvt. T. O. Arrived at a base hospital November 10, 1918, with perforating injury to right eye. Findings: Vision O. D.=blind. Tension very soft, chemosis of conjunctiva, perforating entrance wound over lower inner sclera, and a second skin wound just above the inner canthus. Vision O. S.=20/20, and showed no pathology. X-ray showed two foreign bodies, one small, near nose above inner canthus, and the other estimated to be 5 by 5 by 6 mm. to the temporal side of and opposite the posterior one-third of the globe of the right eye. November 20: Enucleation under general anesthesia. A small and friable foreign body was found lodged in the attachment of the internal rectus, and seemed to be rock or dried hard earth. The other had passed through the globe from below internal to the outer, upper, posterior quadrant, and was lodged in Tenon's capsule, requiring considerable effort to dislodge it. The measurement agreed with the above radiographic estimate, and was a metal splinter of high-explosive shell. The wound was clean to inspection; iodine was applied, the muscles and capsule were closed with chromic gut No. 1, and the conjunctiva with silk. November 25: Patient lost by evacuation.

Comment: It seemed that the foreign body had spent its force sufficiently to be retarded just enough to lodge in the capsule structure after passing through the globe, and did not escape into the orbital fat.

Cases of orbital cellulitis were fairly frequent, as was to be expected, but presented no especially new problems, yielding very quickly to proper drainage with the removal, if possible, of any foreign material which had been the basis of the cellulitis.

Three cases, however, were seen of infection of the orbit by the *B. welchii* with the production of a very serious type of cellulitis.

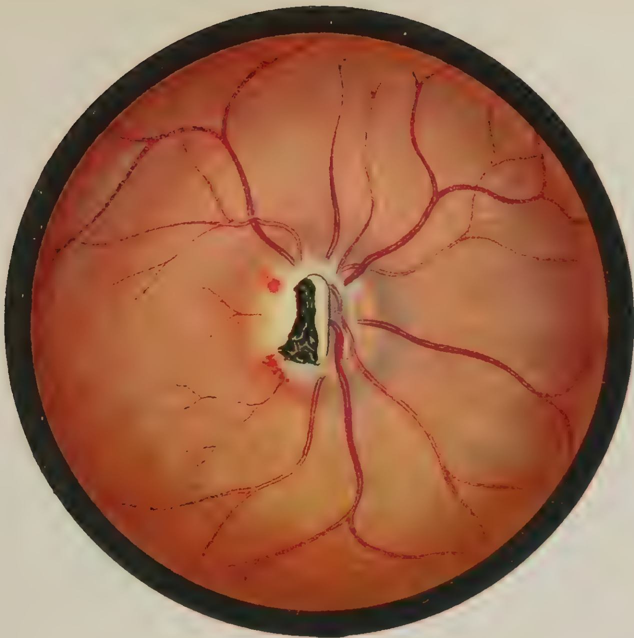
INTRAOCULAR FOREIGN BODIES.

The importance of this class of ophthalmic injuries can not be overestimated, especially when one realizes that in numerous cases the successful removal of an intraocular foreign body may mean the saving of vision in a remaining eye. No accurate figures can be given as to the proportion of magnetic and nonmagnetic foreign bodies found in the hospitals of the American Expeditionary Forces. This proportion varied according to the period of the war and the method of fighting. During the periods of trench warfare many intraocular foreign bodies were composed of bits of sand or gravel and occasionally unexploded bits of T. N. T. from hand grenades. During the period of barrages the great majority were magnetic fragments from high-explosive shells which usually penetrated beyond the iris and lens into the vitreous chamber, some passing through the vitreous and becoming embedded in the retina, choroid, and inner layers of the sclera. These latter were frequently to be seen with the ophthalmoscope, if their passage through had not involved the lens and thereby caused this structure to become opaque. Two very good examples of this condition are shown in Plates IV–A and IV–B, made from cases seen in one of the base hospitals. The condition shown in Plate IV–A is very unusual in that the foreign body is embedded in the optic disc. When the foreign body was lying free, as was usual with those in the vitreous chamber, it was often seen with the ophthalmoscope if the lens was clear and the vitreous not too cloudy with opacities or blood clots. Frequently the foreign bodies moved in the vitreous when the eye turned. Usually the excursion of the foreign body in the vitreous was slight but occasionally was very free, the first movement being rapid, with the return motion slower, often reminding the observer of a penny dropping with an oscillating motion through water.

At one period the Germans used aluminum for the noses of shells, and when a bit of this substance penetrated into the vitreous chamber the eye held a nonmagnetic foreign body of which it was very tolerant. A case was watched for several weeks in one of the base hospitals where the left eye held a silvery appearing foreign body lying on the retina. During this time the foreign body lost none of its silvery luster and the eye seemed unaffected by its presence.

Fragments of brass-shell noses or bits of copper or brass from exploding cartridge shells which had penetrated into the vitreous chamber constituted foreign bodies of which the eye was quite intolerant.

In the treatment of all intraocular foreign bodies it was soon realized that the procedure to be followed in each case must be fitted to the conditions found, according to the best judgment of the operator. It was difficult to formulate definite rules or to follow them. In general, however, it can be stated that the problems were materially affected by the following considerations: First, the size of the foreign body; second, its location; third, the length of time it had been in situ.



A. INTRAOCULAR FOREIGN BODY AS SEEN WITH OPHTHALMOSCOPE; FOREIGN BODY EMBEDDED IN DISC.

B. INTRAOCULAR FOREIGN BODY.

The size was of paramount importance when considering the question of saving the eye and conserving vision. The larger the foreign body, other things being equal, the more devastating was the result to the tunics and interior of the eye. Where the eye was badly torn and the interior filled with clotted blood and stirred-up ocular contents, the problem arising was the question of enucleation or evisceration. Moderate-sized foreign bodies, say from 4 to 2 mm. as to long and short dimensions, were removed sometimes by magnet or otherwise, leaving a fairly good-looking, though usually visionless, eye. Of course, the retention of such eyes after removal of the foreign body depended largely on the position of the wound of entry and the subsequent behavior of the eye during the healing process and later, for the occurrence of an incurable iridocyclitis made enucleation imperative. The smaller foreign bodies, from 2 mm. to ½ mm. as to long and short dimensions, which formed the larger number of such cases, were the ones most amenable to operative procedure, and often were removed successfully, i. e., with a resulting good and prompt recovery and often a useful eye. This was especially true of the small magnetic foreign bodies which were often rounded tiny scalelike bodies less than 1 mm. in diameter.

The nonmagnetic foreign bodies, if anterior to the vitreous, were removed by introducing forceps through a corneal incision. (It was found best to make such an incision with a Graefe knife, held as for a Saemisch section, and cutting straight forward, thus not beveling the incision.) Foreign particles lying in the anterior chamber were washed out by using an irrigator. Those embedded in the iris came out with a section of iris by doing an iridectomy. Those in the lens, eventually causing cataract, were removed when the consequent cataractous lens was extracted.

Nonmagnetic foreign bodies in the vitreous were the most difficult of all to handle. It was occasionally possible to remove them by using forceps introduced through a conveniently located scleral incision and watching the movements of the forceps in the vitreous with an ophthalmoscope. The officer in charge of the ophthalmic service in one of the forward base hospitals submitted a report of a case which illustrates this method of handling these most difficult cases. He reported the removal of a small, glistening aluminum foreign body in the vitreous through a posterior sclerotomy, watching and guiding the forceps with the aid of the ophthalmoscope.[6]

The report of another case which is interesting from the same standpoint follows:

CASE 17.—Patient was admitted to a base hospital October 11, 1918, having been returned from the front on account of foreign body, right globe. History of injury to right eye by flying particles from high explosive. Had had little discomfort, but almost complete loss of vision in the injured eye. Findings: Vision=O. D., fingers at 1 foot in restricted lower central field; pupil was one-half dilated and reacted consensually and to convergence; the cornea, iris, and lens were clear and through the latter could be seen a white and clean metallic mass about 4 mm. by 1½ mm. lying upon folds of detached retina in the lower inner quadrant. A closed scleral wound was detected over the inner scleral area. The appearance of this bright object was unique and reminded one of a jewel set on gray velvet. The eye had had atropine and was quiet. Vision O. S. = 20/30, pupil reacted normally and no other changes from normal were seen. Patient was prepared for removal of foreign body through posterior route and on October 21, under general anesthesia, a conjunctival flap was laid back and a meridional scleral incision 5 mm. long was made with angled keratome. A loop improvised from a soft probe was used to engage the foreign body and it was

easily extracted under direct observation through the clear lens and under its magnification. The scleral lips were adjusted and the conjunctiva closed. The wound healed with very little reaction. The foreign body measured 1 by ⅓ mm. and was white metal, probably from the timing cap of a high-explosive shell. November 9 the eye was clear and the pupil reacted slightly to direct light. In reporting the case the observer commented that this was the most beautiful foreign body within the globe that he had ever seen. "The direct observation through the clear and magnifying lens during its removal was unusual but most helpful. The apparent size as compared to actual measurements after removal was interesting and enlightening. The lens remained clear but the retina was largely detached by proliferative chorioretinitis, traumatic."

The following cases of intraocular foreign bodies are of interest:

Case 18.—F. J. B., injured October 5, 1918, by being struck in the face with shrapnel. There was a penetrating injury of both eyes. The left eye was so badly torn that it was enucleated. The right eye was as follows: Vision, 20/30; fields, normal; cornea, two pigmented spots deeply situated, but causing no irritation; iris, normal; lens, clear; vitreous, cloudy; fundus shows a large foreign body lying on the temporal side of the nerve head, with considerable congestion of the nerve head and the surrounding fundus. (Plate V–A.)

Case 19.—Sgt. W. O., wounded on the Velse, September 14, 1918. Entered hospital September 17, 1918. Diagnosis: Gunshot wound (shrapnel). There is a small penetrating wound in the left temporal region near outer canthus. The left eye is slightly proptosed with injected conjunctiva. The cornea is clear. Near the limbus at 1 o'clock there is a hernia of the sclera into which the iris and ciliary body have prolapsed. The fundus shows the usual concussion changes—vitreous opacities with widespread retinal hemorrhages. Eye blind. X ray report: Three small foreign bodies in globe, one behind globe in or near optic nerve and one in ethmoid sinus. (Fig. 12.) Attempts to extract the foreign bodies from the globe with giant magnet failed. October 5, 1918: Enucleation of globe with implantation of calf cartilage in Tenon's capsule. November 10, 1918: Eye quiet, good movement; artificial eye fitted. O. D., fundus normal.

The small magnetic foreign body in the vitreous furnished by far the most interesting and instructive, as well as the greatest number of problems. Ophthalmic medical officers tried different methods of removal according to their varied training, their hospital location, and the instruments with which they had to work. Officers in evacuation and mobile hospitals, where the rush of recently wounded made a careful localization of the foreign body by the Sweet method of X-ray localization difficult, generally removed very small foreign bodies by what is called the anterior route. Briefly, this consisted of a careful approach of a giant magnet to the uncocainized eye, suspected of harboring a small magnetic fragment. When the magnet, with current on, was brought near enough to exercise a pull on the foreign body, pain was experienced by the patient, thus establishing the fact that the foreign body was magnetic. This use of the magnet for diagnosing the presence of a foreign body, where suspected, and for determining the magnetic qualities of foreign bodies already known to be present, was very satisfactory. When the diagnosis and qualities of the small foreign body had thus been determined the eye was cocainized and the giant magnet slowly brought closer to the cornea, whereupon, in many cases, the foreign body would be pulled through the zonule and up against the posterior surface of the iris. A bulging of this membrane would then require that the pull of the magnet come from the other side of the eye so as to draw the foreign body between the posterior surface of the iris and anterior surface of the lens and thus into the anterior chamber. The minute the foreign body was in the anterior chamber the current was turned off. After the usual methods of cleansing and antiseptic preparation had been followed the lids were separated, a small keratome incision was made above and the foreign body

A. CASE 18. FUNDUS OF RIGHT EYE SHOWING LARGE FOREIGN BODY LYING ON TEMPORAL SIDE OF NERVE HEAD, WITH CONGESTION OF NERVE HEAD AND SURROUNDING FUNDUS.

B. APPEARANCE OF EYE AFTER EXPOSURE TO MUSTARD GAS

FIG. 12.—X-ray plate showing foreign bodies.

was drawn up to and through the incision by the tip of a hand magnet placed on the outside of the cornea. It was not necessary to introduce the tip into the anterior chamber. It was possible to draw the foreign body from the anterior chamber with the giant magnet if a hand magnet was not available. This method of diagnosis and removal was used by ophthalmic surgeons and the consultants in the front line hospitals during active periods, and by some of them this method was considered the one of choice for minute fragments in the vitreous even when accurately localized by the X ray.

The majority of the ophthalmic surgeons in the American Expeditionary Forces, however, were in favor of what is known as the posterior route, especially those working in the hospitals farther from the front, where X-ray localization was more practicable. After the localization, and under antiseptic precautions, a conjunctival flap was made over the area of the sclera nearest to the position of the foreign body, a position in a quadrant between two of the recti muscles being chosen. With a Graefe knife an incision was then made longitudinally in the sclera and the tip of a hand magnet inserted between the lips of the incision, or even thrust into the vitreous. It was important that the tip should never be inserted into the vitreous farther than was absolutely necessary and should be moved around as little as possible. Sometimes several attempts were necessary before the foreign body would come to the tip of the hand magnet. The giant magnet was often used to bring the foreign body close to the wound, where the hand magnet could then be employed to better advantage. Some of the ophthalmic surgeons preferred this method to all others and had no desire for a giant magnet, feeling that with accurate X-ray localization and a hand magnet all foreign bodies could be taken care of.

The experiences of ophthalmic surgeons in the American Expeditionary Forces were not extensive enough, nor are there available sufficient statistical tables with end results to warrant a definite statement as to which method was most suitable for the majority of cases. It is doubtful if the differences of opinion as to magnet methods for the small foreign bodies will ever be settled, for with the choice of two routes, both of which give good results, there will be some who prefer one and some the other. Many will train themselves to both methods, using one or the other according to the dictates of their best judgment.

The following cases well illustrate some of the points made above:

Case 20.—Patient entered one of the advanced base hospitals with the history of feeling something strike his left eye while under shell fire three days before. The eye was very slightly congested and in the cornea close to the limbus there was a small opaque area with just below it a minute hole in the iris. Without waiting for an X-ray examination the large magnet was used to determine if a magnetic foreign body could be demonstrated. On approaching the magnet to the eye the patient complained of a twinge of pain. The eye was cocainized and the magnet brought close to the cornea over the opening in the iris. Immediately on turning on the current a minute foreign body came through the opening into the anterior chamber. A keratome incision was then made and the foreign body drawn out, still using the large magnet. The foreign body was a thin scale about the size and shape of a very small pinhead. Practically no more traumatism was caused by the removal than had been caused by the entrance of the foreign body, and certainly less traumatism in this particular case than would have been caused by an opening in the sclera with the introduction of a magnet tip.

Case 21.—On December 8, 1918, another patient was seen at a camp hospital and the diagnosis of traumatic iritis was made and local treatment instituted. December 10, patient was sent on to a base hospital, where it was noted that the vision of the left eye was blurred, and an X-ray examination was ordered. The next day the diagnosis of foreign body in the eye and acute iritis was

recorded, and after several more days of local treatment the man was dispatched to another base hospital where, on December 16, vision of 20/30 was noted for the right eye and 1/200 for the left eye. It was noted that the left cornea was hazy, the pupil partly dilated, photophobia and lacrymation were present and the fundus was unobtainable with the ophthalmoscope. The conclusion was reached that the patient had iridocyclitis. A Sweet localization performed the same day showed a foreign body 1 by 2 mm. below the horizontal plane of the cornea, 11 mm. to the temporal side of the vertical plane and 13 mm. posterior to the center of the cornea. Inspection revealed a sensitive, photophobic, and lacrymating eye; marked ciliary congestion and contracted pupil, with large, dense, posterior synechia nasally, binding iris to lens, the latter being cataractous nasally and centrally. Due to this condition of the lens, and to a probable large vitreous hemorrhage, no fundus details could be obtained with the ophthalmoscope, a mere red reflex being present around the limited focus of the cataract. Twenty-four hours later a conjunctival flap was made and a sclerotomy performed at the temporal equator. The fine sterilized point of the small magnet was inserted just below the tendon of the external rectus muscle and the foreign body removed without mishap.

The following extract from a report submitted by the officer in charge of the ophthalmological service of Base Hospital 115, the special head hospital, gives the results of the observations of the ophthalmic surgeons on duty with that unit relative to the operative treatment of intraocular foreign bodies:[7]

It is assumed that a penetrating body has not carried with it infection and this discussion deals with eyeballs which are in a fair way to be saved after the removal of the foreign substance.

Diagnosis.—Experience has repeatedly shown that the absence of a visible avenue of entrance is a thoroughly unreliable guide in the diagnosis of the presence of a foreign body in the globe, nor, if present, does the apparent path through the media furnish reliable information as to its ultimate location, unless, of course, the body is plainly visible to the ophthalmoscope. In a similar way, the history is totally to be disregarded. I deprecate the use of the giant magnet as a means of diagnosis. The exposure of an eyeball to the giant magnet without previous knowledge as to the size, location, and position of the entering body may do infinite and irreparable harm. Enough information can not be gained to warrant the practice.

The final diagnosis must rest with the roentgenologist, and to the roentgenologist the suspected case should be sent promptly. How many exposures should be made? There is no set number, but enough to establish not only the definite localization of the particle, but, what is of equal importance, its several dimensions. It is quite obvious that photographs exposed in two planes only (as is usually done) can not provide this information—always three and sometimes four are needed. Too much emphasis can not be placed upon the necessity of knowing the three dimensions, for upon this knowledge must rest the rational selection of the method and route to be chosen for its extraction.

Route and method.—In the selection of the route and method of extraction, the surgeon should be governed solely by the location, shape, and size of the foreign body.

Size and shape.—It is obviously very difficult to lay down didactic rules for the selection of the best route and method for all cases. However, a rationale may be indicated. That method and route should be selected which shall produce the minimum of damage to essential ocular structures, and be most likely free from deleterious aftermath. If the invading body is small, roundish, and presents no ragged edges which may become entangled in the wound or ciliary structures in processes of delivery, the anterior route by means of the giant magnet presents the least surgical risk. If, on the other hand, the foreign body is rectangular, though smooth, and too long to pass through the suspensory ligament, posterior chamber, and pupil, the scleral route is the one offering least risk. If the foreign body, though small, presents ragged, irregular notches and facets which are likely to entangle and damage the structures through which it must pass to effect delivery, here, again, the posterior route is the one of election.

Location.—Whatever the size and shape of the foreign body, if lying against the ciliary body in such a position that there is likelihood of its becoming impacted in the ciliary body upon exposure to the tractive force of a powerful magnet, this fact alone should urge the selection of the posterior route.

To summarize.—The posterior route is preferable as offering the minimum of risk in all cases except those of small smooth foreign bodies not lying against the ciliary body.

Operative procedure.—General considerations: The patient should be prepared as for any major ocular surgical operation. This includes trimming of the eyelashes and wrapping the head in a sterile covering, preferably moist to prevent slipping. Both magnets should be covered with sterile jackets. For the giant magnet, a pillow slip with one corner cut out does well enough. This permits the operator to tilt and direct the magnet. A towel suffices for the hand magnet. These coverings should be secured by safety pins or tapes. The various magnet tips should be boiled or effectively sterilized. The magnets should be provided with a rheostat switch directly under the operator's control.

Instruments: A nonmagnetic speculum is essential for both routes. For the posterior route two nonmagnetic forceps and two nonmagnetic mosquito hemostats are necessary. Nothing is more awkward or disconcerting than to have the instruments fly to the magnet when the current is turned on.

Illumination: Good light is essential. Artificial light, owing to the ease of its control is best some type of hand lamp so hooded as to illuminate the operative field and not dazzle the operator's eyes and in the hands of an intelligent nurse is ideal.

Anterior route: Giant and hand magnets. The pupil having been dilated to its maximum and the eye cocainized the patient is placed on a stool before the magnet. I prefer to sit facing the patient as being the more comfortable position in which to manipulate and observe. Either the magnet is tilted or the patient's head is turned so as to cause traction in the line indicated by the radiograph. The patient is slowly brought nearer the magnet. As soon as the foreign body has passed through the suspensory ligament and its presence in the posterior chamber is evidenced by the bulging of the iris, the direction of magnetic pull must be immediately changed to one of obliquity so as to attract the fragment through the pupil. Continued exposure in the first position may impact the metal in the iris. When the foreign body has passed into the anterior chamber, the patient is removed to the operating table to complete the extraction by means of the hand magnet. By means of this magnet the fragment is attracted to the upper quadrant of the anterior chamber near the contemplated incision. It is a mistake to draw the foreign body deep into the angle, out of sight, but it should be left near the base of the iris where plainly seen. From now on it should be the chief aim of the surgeon to preserve the aqueous as long as possible. The anterior chamber is now opened with a keratome, promptly and in such a way as not to drain the aqueous. The keratome incision should not be at the level of the iris root, but well above it, and directed nearly perpendicularly through the cornea in the direction of the fragment. The magnet tip is then applied to and not introduced into the wound. The assistant stands with the scissors ready to clip the iris should it, through some mishap, present. If the aqueous has been preserved, the fragment will glide promptly to the incision, where it can be delivered by the assistance of a fine forceps, should the magnetic force be sufficient.

Posterior or scleral route with hand magnet: The patient is placed on the operating table after the usual preparation made for any operation. The magnet is within ready access when needed. In addition to the usual anesthesia obtained by the installation of cocaine, a subconjunctival injection of a 1 per cent cocaine and adrenalin solution is made at the site of the contemplated scleral opening. This insures not only good anesthesia, but a bloodless field. This incision should be planned to be made as near the foreign body as practicable, bearing in mind the avoidance of the ciliary body, the insertions of the recti muscles and in the lower quadrants rather than the upper. The bleb raised by the hypodermic is now seized with the forceps and a deep cut made in an anteroposterior direction, with a bold stroke of the scissors. This cut includes conjunctiva, and subconjunctival tissue, exposing the sclera. The two flaps are now undermined for ten or more millimeters in either direction. A double suture is now placed in the center of each flap margin, incorporating a firm anchorage. These sutures are secured by mosquito hemostats and are used as retractors. The sclera is sponged free from hemorrhage and an incision is made through the sclera with a sharp well pointed von Graefe knife. The incision should be adequate for the delivery of the foreign body and in the direction of the retinal vessels, anteroposterior. The magnet is then presented to the wound. Meantime, the assistant stands ready with the scissors to trim away the choroid should it present. Upon the delivery of the foreign body the wound is promptly closed by tucking one flap under the other and covering the first by the remaining flap, in such a way as to utilize the flaps as tractors approximating the lips of the scleral wound, and at the same time seal and reinforce the wound by a double layer of conjunctiva. * * *

A further word concerning the conjunctival flap as described above. An important step in the technique is the provision made for closing the wound before making the scleral incision. This minimizes the danger of prolapse of vitreous through unnecessary manipulation with an open vitreous wound. In addition to this, the flaps furnish splendid retractors making the exposure of the scleral wound sure and certain without the necessity of retraction of the conjunctiva by forceps, thereby cluttering up an operative field already too small. In many instances when not able to have trained assistance I have allowed the weight of the hemostats to retract the wound lips. With this in mind, it is well to have the threads long enough to permit the hemostats to hang over the patient's face.

These wounds, in my experience, heal kindly and promptly. I have never seen a gaping scar or bulging cicatrix.

The after-care of these patients requires no special comment. As a routine they are given sodium salicylate, 40 grains daily for a few days. The sutures are removed in six to eight days.

Conclusions.—Unreliability of case reports and statistics: One naturally turns to reported cases and statistics in seeking guidance for the selection of a satisfactory method for the removal of foreign bodies from the globe. I voice my personal opinion upon the value of such data by saying that they seem quite unreliable unless collaborated from cases which are similar in essential respects as to size, shape, and position of the foreign bodies and also to the amount of damage done upon entering the globe and the reaction they excite. The choice of an operative route seems more rationally to rest upon the selection of a method which will produce the smallest surgical trauma and do the least damage to essential structures. This, in turn, must depend, not upon a fixed procedure, but a procedure best adapted to the case in hand. I can not be convinced that it is wisdom to drag an irregularly shaped ragged piece of steel around the lens and through the pupil and, on the other hand, I believe there is a minimum of risk involved by using this route for a small smooth fragment.

SYMPATHETIC OPHTHALMITIS.

With the occurrence of a large number of injuries to the anterior portion of the eye there was noted in the American Expeditionary Forces a surprising absence of sympathetic ophthalmia. No case of blindness from this cause was recorded. This lack of cases of severe sympathetic ophthalmitis can be accounted for in three ways: First: All eyes so badly injured in their anterior portions that there was no hope of saving a useful eye were enucleated or eviscerated at once. Second: Less devastating anterior injuries were treated antiseptically and often the wounds were sealed by a well-placed conjunctival flap, with the result that prompt healing took place without being followed by iridocyclitis. Third: The most important preventative of sympathetic ophthalmia lay in the enucleation of all injured eyes which developed a persistent iridocyclitis. It was the consensus of opinion that an injured eye which did not develop an iridocyclitis would not cause sympathetic ophthalmitis. The difference between civilian and military ophthalmology in regard to the prevalence of sympathetic ophthalmitis lies wholly in the fact that in civilian life patients often refuse to allow the enucleation of an eye which, by reason of a traumatic iridocyclitis, endangers the fellow eye, while in military life such eyes are removed at once.

One case of a beginning sympathetic ophthalmitis was seen in an evacuation hospital. A soldier had received a nonmagnetic foreign body which had penetrated into one eye resulting in a severe traumatic iridocyclitis. After three weeks of this severe uveal inflammation, the good eye began to show signs of sympathetic uveitis, sluggish pupil reaction, slight iritis, and disturbed vision. The injured eye was at once removed, and the patient was given salicylates; in a few days all signs of sympathetic ophthalmitis had disappeared.

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A number of cases of sympathetic irritation in the good eye were observed. The ophthalmic surgeon in one of the base hospitals reported three cases of frank sympathetic irritation due to ultra-conservatism and the desire to save the primarily injured globe if possible.[8] These all showed, one to three weeks after injury, slight ciliary congestion, blepharospasm, excessive lacrymation, and hyperemia of the papilla, with blurring of its margins in the unaffected eye, the patient experiencing at the same time in that eye such annoying subjective symptoms as photophobia, slight, sharp, pricking pains in the globe, and alternating phases of blurred and clear vision. He reported the following case:

Case 22.—J. S. G., aged 23, February 23, 1918. At 4.30 a. m. January 24, 1918, patient looked over the top of the trench and received a piece of an exploding grenade in the left eye. Ten minutes later the first-aid man painted the cut in the lid with iodine. He suffered great pain and was taken to the infirmary at 7 p. m., thence to a field hospital, where he was anesthetized, his injured eye thoroughly examined, and no wound of the globe found, the cut in the lids being the only discoverable lesion. He was retained here for two days and then sent to another field hospital, where he was kept in bed with cold compresses for five days, during which the pain continued. For the first five or six days he insists he was blind in the right eye. A dressing was put over his eye and he was kept in bed for an additional five days and then allowed to be up and about until he was evacuated to a base hospital, one month after the receipt of the injury.

Present condition: Wound, multiple, involving both lids and the globe of the left eye. The eyeball is semiphthisical, soft, its tunics congested, the iris mud-colored, with stromal texture obliterated and retracted by posterior-lying cyclitic membrane; the anterior chamber is deep, and the pupillary space filled with a densely organized exudate through which but a faint fundus reflex is obtainable with the ophthalmoscope. The right eye manifested marked blepharospasm, lacrymation, and photophobia, with hyperemia of the conjunctival and ciliary vessels, while the ophthalmoscope shows dark, distended retinal veins and hyperemic papilla. V. O. D.=20/30, V. O. S. blind. X-ray examination advised and showed a foreign body in the left orbit. Because of the hopeless condition of the left eye and the sympathetic irritation of the right, enucleation was performed and a large piece of grenade removed from the supranasal lip of the orbital edge of the optic canal.

Diagnosis: Uveitis, proliferating, traumatic, left eye; irritation, sympathetic, right eye; foreign body, orbit, left eye.

Upon performing complete enucleation of the exciting eye the sympathizing eye at once regained the normal.

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CHAPTER II.

SPECIAL STUDIES.

THE BLIND AND NEARLY BLIND.

In the expeditionary forces it was inevitable that some cases of blindness from causes that are common to civilian life should occur, to be augmented later, as the war casualties increased, by those blinded in battle. Of the early cases the following is of especial interest:

Case 23.—Sgt. W. H. Z., aged 31 years. Patient was driving a motor truck which skidded down a hill and tipped over, pinning him beneath and compressing his lower abdomen. He was soon pried out by his companions and rushed to a field hospital, where the diagnosis, "possible fracture of one rib and injury to spine and bladder," was made, and patient immediately sent on to a base hospital.

When admitted patient was quite ill and presented a classic picture of traumatic asphyxia. Deep, dusky color, more marked over face and neck, the tissues being swollen and discolored from the diffuse peripheral hemorrhages. Lids purplish and swollen, so that eyes were closed. Complete bilateral subconjunctival ecchymosis. Ophthalmoscopy: Retinal edema, bilateral, with a few small scattered retinal hemorrhages, one in the macular region of the left retina. Patient at this time too ill to test vision. He did not complain of diminished visual actuity until several days later. In the meantime he was operated upon for fractured pelvis and traumatic rupture of the bladder, the surgeon achieving an excellent result, though the convalescence was delayed by the development of a bronchitis.

During this interim the eye grounds were frequently studied and the absorption of the hemorrhages was noted, as well as the gradual atrophy of the disc, manifested particularly in attenuation of the vessels and paleness, with decrease in level of the temporal sector of the disc and loss in retinal sheen. He rapidly became quite blind, save for a tiny area in his right inferotemporal visual field, which could be quite clearly mapped with the perimeter. Later reports from the general hospital in the United States, where he was treated, state that this latter area entirely disappeared and that he is totally blind.

It was felt that his retinal hemorrhages could account for great loss in visual acuity, especially the macular hemorrhages in the left eye, but as they were absorbed and his vision grew steadily worse, other collateral explanations were sought and the examiner cogitated the possibility, or probability, of hemorrhages into the sheaths of the optic nerves, with pressure upon the latter, and secondary descending optic nerve atrophy, as well as the postretinitic variety. This could be given no more value than the most plausible of many unproved hypotheses. The case is quoted to illustrate the more serious ocular complications of traumatic asphyxia.

The following series represents many of the cases of total or almost total blindness following battle injuries among our forces. The explosion of shell was responsible for the major portion of the battle blindness occurring in the American Expeditionary Forces.

CASES OF TOTAL AND PARTIAL BLINDNESS.

SHELL AND SHRAPNEL WOUNDS.

1. While resting after an early morning attack at 5.30 o'clock July 25, 1918, at Chateau Thierry, he was blinded by a shell which exploded near by. After learning Braille and typewriting, patient died suddenly from cerebral complications.

2. September 29, 1918, at Argonne Forest, while walking during a heavy shelling, he heard a cry for help from a wounded comrade and was assisting him to the dressing station when a shell burst, killing the man already wounded and wounding him. Both eyes enucleated and nose badly injured.

3. October 9, 1918, at Argonne front, received high-explosive shell wound, both eyes, face, lower lid. Foreign body right eye vitreous; also foreign body left eye (nonmagnetic). Vision: 20/40 O. D., light perception O. S. Foreign body both eyes. Traumatic cataract O. S.

4. September 25, 1918, at St. Quentin sector, received shell wound both eyes, chin, and left hand. Optic atrophy right eye due to pressure of foreign body 9 by 15 mm. in size pressing against optic nerve. Left eye opacities in vitreous, and retinitis. Vision: Blind O. D., 7/200 O. S.

5. October 2, 1918, Verdun front, received high-exposive shell wound head, both eyes, left arm, and hip. Unable to see after injury. Totally blind. Phthisis bulbi both eyes.

6. October 11, 1918, on Verdun front, high-explosive shell wound both eyes, head, and face. Following morning remnants both eyes removed. Totally blind.

7. July 15, 1918, on Champagne front, received high-explosive wound both eyes; also injury to right arm, resulting in paralysis radial side. Both eyes enucleated following injury. Totally blind.

8. October 1, 1918, on Verdun front, received high-explosive shell wound and gassed. Injured both eyes and right hip. Both eyes enucleated following day. Ectropion lower lid due to scar beneath right eye October 17, 1918. Totally blind.

9. April 14, 1918, on St. Mihiel sector, received high-explosive shell wound both eyes. Left eye enucleated six weeks later. Traumatic cataract right eye. No light perception. Totally blind.

10. August 8, 1918, at Chateau Thierry, received high-explosive shell wound both eyes, resulting in foreign bodies which were nonmagnetic. Vision: Light perception right eye, 12/200 left eye. Foreign bodies with changes in vitreous both eyes, more marked in right.

11. October 2, 1918, wounded by high-explosive shell in both eyes, right foot, both thighs, left forearm, and right arm near shoulder. Right eye shrunken about half. Left eye enucleated. Totally blind. Phthisis bulbi O. D.

12. September 12, 1918, at St. Mihiel sector, received high-explosive shell wound both eyes, left ear, and chin. Left eye enucleated same day. Right eye enucleated September 25, 1918. Totally blind.

13. November 6, 1918, on Verdun front, received shell wounds both eyes. December 2, 1918, left eye enucleated. Right eye, detachment of retina, lower half. Vision: Light perception O. D.

14. September 27, 1918, on Verdun front, piece of high-explosive shell penetrated right eye. Following day right eye enucleated. Ten days after injury totally blind. Sight began to return slightly in left eye. Vision: 2/200 O. S. Optic atrophy.

15. September 28, 1918, on Verdun front, as result of high-explosive shell bursting within 6 feet of him particles of dirt were thrown into both eyes. Vision: 10/200 O. D., 3/200 O. S. Corneal opacity, bilateral. Traumatic cataract O. S.

16. November 10, 1918, on Argonne front, received high-explosive shell wound both eyes, right wrist, right and left thigh. Right eye enucleated November 11, 1918. Right upper lid drawn in scar located outside of outer canthus. Totally blind. Phthisis bulbi O. S.

17. October 4, 1918, on Argonne front, received injury of both eyes as result of concussion of high-explosive shell. Intraocular hemorrhage right eye. Choroidal rupture left eye on nasal side of disc. Vision: Light perception O. D., 2/200 O. S.

18. July 21, 1918, at Chateau Thierry, received high-explosive shell wound both eyes. As result developed phthisis bulbi, both eyes, with no light perception. Both eyes enucleated. Totally blind.

19. November 1, 1918, on Champagne front, received shrapnel wound of right eye and left arm. Left eye injury probably from concussion. Enucleation right eye. Choroidal rupture lower right quadrant fundus left eye. Vision: 4/200 O. S.

20. July 18, 1918, near Soissons, France, received high-explosive shell wound both eyes, face, and body. Left eye enucleated following day. Detachment of retina and dislocated lens O. D. Totally blind.

21. October 2, 1918, on Verdun front, received high-explosive shell wound of face and both eyes. Both eyes shrunken about one-third normal size November 10, 1918. Totally blind. Phthisis bulbi, bilateral.

22. September 18, 1918, on Soissons front, received high-explosive shell wound both eyes. Right eye enucleated three weeks later. Left eye reveals choroidal rupture surrounding disc extending downward and outward. Totally blind.

23. Age 20. September 10, 1918, near Soissons, received shell wound left side of face, right eye, and right arm. Right eye enucleated. Optic atrophy left eye. Considerable loss of tissue and bony structures beneath right eye requiring plastic operation. Totally blind.

24. June 6, 1918, at Cantigny, received shrapnel wound both eyes. Right eye enucleated following injury. Penetrating wound left eye, with resulting traumatic cataract.

25. September 28, 1918, in Verdun sector, received high-explosive shell wound both eyes and left arm. Right eye shrunken about one-fourth of its normal size. Lower lid drawn into scar beneath lid. Left eye shrunken to half its normal size. Totally blind. Phthisis bulbi, bilateral.

26. October 14, 1918, in Verdun sector, received high-explosive shell wound both eyes and head. Right eye enucleated at this time. Left eye markedly shrunken. Upper lid left eye drawn into scar above. Totally blind. Phthisis bulbi O. S.

27. August 18, 1918, at Allichamp, received high-explosive wound both eyes. Right eye enucleated following injury. Left eye revealed large proliferating mass in vitreous. Light perception O. S. Retinitis proliferans O. S.

28. September 28, 1918, in Verdun sector, received shrapnel wound both eyes. Right eye enucleated. Left eye shrunken, and no light perception November 6, 1918. Totally blind. Phthisis bulbi O. S.

29. September 27, 1918, in Verdun sector, received high-explosive shell wound of both eyes with complete destruction of both eyes and lower lid left eye. Remnants of eyes removed following injury. Totally blind.

30. November 7, 1918, in Argonne Forest, received high-explosive shell wound both eyes. Following day left eye enucleated. Right eye revealed choroidal rupture completely destroying nerve-head and extending downward and outward. Totally blind. Choroidal rupture O. D.

31. October 8, 1918, on Champagne front, received shrapnel wound, entering right side of face below malar bone and coming out in lower part of left eye. Right eye shrunken. Left eye choroidal rupture extending downward and outward from disc. Vision: Blind right eye, 2/200 left eye. Phthisis bulbi O. S. Choroidal rupture O. S.

32. October 27, 1918, on Argonne front, received high-explosive shell wounds, resulting in total blindness. Right eye revealed detached retina, intraocular hemorrhage. Left eye enucleated. Lower left eye drawn into scar beneath. Totally blind.

33. October 14, 1918, on Verdun front, as a result of high-explosive shell wound, both eyes severely injured. Both eyes enucleated shortly after injury. Has large granulomatous mass lower lid right eye. Totally blind.

34. October 7, 1918, on Verdun front, received high-explosive shell wound both eyes. X ray. revealed foreign body 1 by one-fourth inch inside skull, temporal region, on line with top of orbit. Totally blind. Optic atrophy O. D. Phthisis bulbi O. S.

35. September 28, 1918, on Argonne front, received high-explosive shell wound both eyes. Examination revealed both eyes shrunken about one-third normal size. Also adhesions between upper lid and left eyeball. November 4, 1918, vision: 6/200 O. D., blind O. S. Intraocular hemorrhage choroidal rupture and retinal detachment O. D. Enucleation O. S.

36. September 27, 1918, totally blinded at Argonne Forest by high explosives. Struck full in face by shell, which tore helmet to pieces and cut face. Two days after injury both eyes enucleated. Totally blind.

37. July 17, 1918, at Chateau Thierry received shrapnel wound left side of head, injuring both eyes. Examination right eye shrunken about one-third. Left eye revealed choroidal rupture extending from nasal side of disc around disc to macula. Totally blind. Phthisis bulbi O. D.

38. October 1, 1918, at Argonne front, received high-explosive shell wound both eyes, both hands. Perforation of ear drum. Totally blind. Enucleation both eyes.

39. May 21, 1918, at Pas France, as a result of high-explosive shell, was blown about 10 feet, which produced double inguinal and umbilical hernia. One week later vision right eye was affected. Examination revealed traumatic cataract. Vision: Right eye blind, left eye 20/70. Traumatic cataract O. D. Amblyopia O. S. due to divergent strabismus.

40. June 9, 1918, at Chateau Thierry, received high-explosive shell wound both eyes, right hand, face, and body. June 14 left eye enucleated. Right eye shrunken about one-third. Totally blind. Phthisis bulbi O. D.

41. October 11, 1918, on Champagne front, received shell wound both eyes, face, and hand. Has been unable to see since injury. Both eyeballs shrunken and irregular in shape. Totally blind. Phthisis bulbi bilateral.

42. October 11, 1918, on Argonne front, received shell wound, which entered right side of face, coming out left side. Completely blinded following injury. Sight gradually returned left eye. Right eye shrunken. Choroidal rupture from disc to macula left eye. Vision: Blind right eye, 3/200 left eye.

43. June 5, 1918, at Cantigny, received shell wound both eyes, right ankle, right knee, and right hand. Right eye traumatic cataract. Discission was done on this eye. Because of vitreous changes practically no vision was obtained. Could count fingers with right eye at 1 foot. Left eye enucleated.

44. October 14, 1918, on Verdun front, received shell wound both eyes. Examination right eye revealed intraocular hemorrhage and detachment of retina. Left eye phthisis bulbi resulting from penetrating wound. Totally blind.

45. October 5, 1918, in Argonne sector received high-explosive shell wound, entering left eye, coming out right side of face. Left eye enucleated shortly after. Examination right eye revealed choroidal rupture nasal side of fundus and detachment of retina, also optic atrophy. Totally blind.

46. September 15, 1918, in Somme sector, received high-explosive shell wound both eyes, right shoulder and right knees. Both eyes enucleated two days later. Totally blind.

47. September 29, 1918, on St. Quentin front, received high-explosive shell wound right hand, right leg above knee, and both eyes. Examination: Right eye disc atrophic, left eye shrunken about one-half. Totally blind. Optic atrophy, right eye, phthisis bulbi left eye.

48. October 11, 1918, on Flanders front, received high-explosive shell wound both eyes. Result, complete blindness. Right eye enucleated five days later. Left eye shrunken about one-third.

49. Age 25. October 5, 1918, on Verdun front, received shell wound both eyes and upper part of face, with considerable loss of tissue in bony structures. Following day remnants of both eyes removed. Totally blind.

50. September 5, 1919, at Chateau Thierry, received shell wounds both eyes. Examination right eye revealed choroidal rupture extending outward and upward from macula. Left eye revealed optic atrophy and disseminated choroiditis. Vision: 10/200 O. D.; able to count fingers at 6 inches with left eye. Choroidal rupture O. D. Optic atrophy and disseminated choroiditis O. S.

51. October 7, 1918, in Argonne front, injured by high-explosive shell both eyes, right hand, and left knee. Right eye enucleated four days after injury. Left eye shrunken. Totally blind. Phthisis bulbi O. S.

52. November 1, 1918, on Toul sector, received high-explosive shell wound both eyes and left arm. December 11, right eye enucleated. Left eye revealed traumatic cataract, which is undergoing absorption. Vision: O. S., good light perception.

53. November 11, 1918, at the Argonne front, received high-explosive shell wound in region of left occipital lobe. Sight was affected immediately. Perimeter showed sharp line cutting off left half of each retina. Wernicke test showed lesions to be posterior to the primary optic nucleus. Vision: 1/200 in each eye. Left homonymous hemianopsia.

54. October 16, 1918, on Verdun front, received shell wound, which entered between outer canthus left eye and ear, coming out right eye. Right eye enucleated shortly after injury. Left eye revealed choroidal rupture, detachment of retina, and phthisis bulbi. Totally blind.

55. August 9, 1918, on Flanders sector, received high-explosive shell wound of both eyes and head. Left eye enucleated shortly after. Right eyeball shrunken about three-fourths. Totally blind. Phthisis bulbi O. D.

56. July 15, 1918, on the Marne, received high-explosive shell wound of both eyes and upper part of face. Examination revealed both eyes shrunken about one-third and irregular in shape. Totally blind.

BULLET WOUNDS.

57. October 4, 1918, on Champagne front received machine-gun bullet, destroying both eyes. Following morning both eyes enucleated. Totally blind.

58. October 31, 1918, on Flanders front, received bullet wound, entering left eye, coming out between right eye and right ear. Three days later left eye enucleated. Right eye shrunken. Totally blind. Phthisis bulbi O. D.

59. July 31, 1918, at Chateau Thierry, received machine-gun bullet, entering left eye, coming out right eye. Remains of both eyes enucleated same day. Partial loss of left lower lid. Adhesions of lid to socket O. S. Totally blind.

60. July 28, 1918, at Chateau Thierry, received machine-gun bullet, entering right eyebrow inner side. Two days later right eye enucleated. Seven days later left eye also enucleated. Totally blind.

61. September 5, 1918, on Verdun front, received machine-gun bullet, entering left side of face, coming out right side of face just below outer canthus. Complete detachment of retina right eye. Choroidal rupture left eye. Vision: Light perception O. S. Blind right eye.

62. September 23, 1918, on Toul front, received rifle bullet, injuring right side of face and eye, with considerable loss of bone and tissue below right eye. Left eye revealed choroidal rupture extending from disc to macula. Vision: Blind O. D., 20/200 O. S. Right eye enucleated.

63. Age 26. September 29, 1918, on Verdun front, received bullet wound, which entered right side of face, coming out left eyebrow. As a result developed phthisis bulbi both eyes. Totally blind.

64. October 4, 1918, on Champagne front, received sniper's bullet, entering beneath left eye, coming out just beneath right eye. Right eye enucleated same night. Left eye enucleated April 15, 1919. Totally blind.

65. October 9, 1918, on Verdun front, machine-gun bullet entered brow right eye, coming out just outside of outer canthus left eye. Examination right eye revealed intraocular hemorrhage, choroidal rupture and retinal detachment. Left eye shrunken about half. Vision: 6/200 right eye, blind left eye. Left eye enucleated.

66. September 14, 1918, on the St. Mihiel sector, received machine-gun bullet, which entered left eyebrow, causing complete destruction of both eyes, upper part of face, base of nose opening up nasal fossæ. Three bullets in right shoulder. Totally blind. Open shell wound upper part of face, requiring plastic operation.

67. July 18, 1918, machine-gun bullet entered right temple, coming out left eye. Following day both eyes enucleated. Upper lid right eye adherent to wound on nasal side; also lower lid. Totally blind.

68. November 9, 1918, on Verdun front, received machine-gun bullet, which entered right side of face beneath right eyebrow, coming out beneath left eyebrow left side of face. Right eye shrunken about one-fifth. Complete detachment of retina O. D. Left eye enucleated November 11, 1918. Totally blind. Retinal detachment and phthisis bulbi O. D.

POISON GAS.

69. July 18, 1918, at Chateau Thierry was gassed (mustard). Developed choroiditis both eyes, as result. Large central patch choroiditis and floating opacities vitreous O. D. Choroidal changes O. S. Vision: Light perception O. D., 8/200 O. S. Disseminated choroiditis, bilateral.

70. June 15, 1918, was gassed (mustard) at Belleau Woods, resulting in dense corneal opacities both eyes. Dense leucomatous scars, bilateral. Vision: Is able to count fingers at 6 inches O. D. Light perception O. S.

71. August 10, 1918, at Chateau Thierry sector, was gassed. August 13, 1918, noticed sight beginning to fail. No history of previous poor vision. Vision: 4/200 O. D. and O. S. Optic atrophy bilateral.

72. July 30, 1918, at Chateau Thierry sector, was gassed. Eyes became inflamed and swollen. August 24, 1918, developed ulcers of cornea both eyes. Vision: 5/200 O. D., 20/200 O. S. Corneal opacities bilateral.

73. July 14, 1918, near Chateau Thierry, was gassed. As result developed conjunctivitis and superficial keratitis bilateral. Vision: 15/200 O. S., 20/70 O. S. Corneal opacities bilateral.

74. October 12, 1918, on Verdun sector, severely gassed, burning eyes, face, hands, and other parts of the body. On November 10, 1919, right eye enucleated because of slough of cornea and panophthalmitis. Left eye revealed dense opacity of cornea. Totally blind.

75. October 1, 1919, on St. Mihiel front, both eyes and face badly burned by mustard gas. Examination of both eyes revealed evidence of chronic inflammation of the lids and bulbar conjunctiva. Dense leucomatous scars covering entire cornea both eyes. Vision: Light perception only, both eyes.

Hand-Grenade Explosions.

76. November 16, 1918, received injury to both eyes, face, both hands, and both limbs from premature explosion of hand grenade. Caused complete blindness and loss of both hands. Totally blind. Phthisis bulbi both eyes.

77. September 15, 1918, at St. Mihiel, received several wounds of face, both eyes, and left shoulder, resulting from hand-grenade explosion. Both eyes enucleated. Totally blind.

78. August 3, 1918, Toul sector, as result of hand-grenade explosion, both eyes, left hand, left leg injured. Numerous opacities vitreous right eye. Foreign body left eye and traumatic cataract. Vision: 10/200 O. D., light perception O. S.

79. Age 25. June 9, 1918, on Viele sector, received injury to both eyes, head, face, and left arm from hand-grenade explosion. August 18, 1918, left eye enucleated. Piece of steel removed right eye September 9, 1918. Vision: 10/200 O. D. Traumatic keratitis, with resulting numerous opacities cornea.

80. Age 23. September 27, 1918, on Argonne front, as result of hand-grenade explosion, both eyes were injured. Right eye shrunken about one-third. Traumatic cataract left eye, with no light perception. Totally blind.

81. Age 27. September 13, 1918, Toul sector, as result of hand-grenade explosion both eyes were injured. Left eye revealed detachment of retina and traumatic cataract.

82. October 29, 1918, on Argonne front, as result of hand-grenade explosion, right eye, left hip, and inner part of right thigh injured. Right eye lens cloudy. Left eye, highly hyperopic. Vision: Can count fingers at 8 inches with right eye. Left eye 20/100. Traumatic cataract O. D. Amblyopia and hyperopia O. S.

83. February 8, 1918, on Lorraine sector, was knocked unconscious by hand-grenade explosion and captured. Unable to see since. Right eye enucleated. Penetrating wound left eye. Totally blind.

84. September 29, 1918, on Argonne front, as result of hand-grenade explosion, both eyes and left hand injured. Right eye enucleated and left hand amputated following injury. Left eye shrunken about one-third. Totally blind. Phthisis bulbi O. S.

85. Age 29. September 22, 1918, at Argonne sector, as a result of hand-grenade explosion, both eyes were injured. Right eye enucleated same day. Left eye revealed traumatic cataract. Deep depression back of ciliary region. Has no light perception. Totally blind.

86. November 2, 1918, while in France as a result of hand-grenade explosion, he was struck in left eye. History of poor vision in right eye before entering the service. Examination revealed choroiditis and optic atrophy right eye. Left eye traumatic cataract. Vision: 10/200 O. D., totally blind O. S. Atrophic choroiditis and optic atrophy O. D.

87. September 27, 1918, at Argonne front, as result of hand-grenade explosion, both eyes, face, and arm injured. Extensive choroidal rupture lower right-hand quadrant right eye. Left eye revealed detachment of retina nearly complete.

Miscellaneous Causes.

88. April 4, 1918, on Verdun front, was gassed. While receiving treatment for this on May 27, 1918, developed spinal meningitis, which affected both eyes. Vision: O. D. 20/70, O. S. 20/50. Partial optic atrophy bilateral.

89. October, 1918, while in Bordeaux, had typhoid pneumonia. While convalescent noticed his eyes were bad. Became totally blind five weeks after sickness began. Probably had meningitis. Totally blind. Optic atrophy bilateral.

90. About May 15, 1918, at Bordeaux, France, sight began to blur, gradually got worse, and became totally blind on August 8, 1918. Eye condition supposedly due to glare from furnace fire of ship. Optic atrophy bilateral.

91. June 12, 1918, eyes first gave him trouble. Examination revealed opacities vitreous. Choroidal and retinal changes both eyes. Highly myopic. Vision: 7/200 O. D., 20/200 O. S. Diagnosis: Chorioretinitis bilateral and myopia.

92. Had been troubled with night-blindness since he was 10 years of age. Stated that his vision was worse since being in service. Examination revealed clumping retinal pigment around terminal branches of retinal arteries both eyes. Vision: 20/200 O. D. and O. S. Retinitis pigmentosa, beginning secondary optic atrophy.

93. September 12, 1918, near Brest, France, developed cerebrospinal meningitis. Two days was unable to see. Both eyes shrunken about ¼ of their normal size. Cornea both eyes cloudy. Totally blind. Phthisis bulbi bilateral due to meningitis.

94. Age 27. August 1, 1918, at Cantigny, France, first noticed his eyes giving him trouble. At that time developed keratitis (interstitial) and conjunctivitis. Cause undetermined. Vision 1/200 both eyes. Corneal opacities bilateral.

95. September, 1918, at Argonne sector, left eye began to pain and vision became blurred. This eye grew worse rapidly until November 20, 1918, when it was enucleated because of acute glaucoma. Right eye tension high. Retinal detachment, fundus reflex present upper part only Vision: 20/100 O. D. Blind O. S.

96. September, 1918, at Mangiere, France, developed influenza. At that time vision became blurred. Sight gradually became worse until March, when he became practically blind. Examination revealed neuroretinitis both eyes.

97. November 3, 1917, while in France, truck skidded and turned over. Patient was pinned beneath. Chest, abdomen, and left side of pelvis injured. At this time had numerous hemorrhages retina of both eyes. Examination revealed optic atrophy both eyes. Totally blind.

Of the above, 59 were totally blind, the rest having some vision and a few a fair vision in one eye, with prospects of some improvement, especially in the cases having traumatic cataracts; 56 were due to injuries resulting from shells or shrapnel; 12 to injuries resulting from bullet wounds; 7 to the effects of mustard gas; 12 to hand-grenade explosion; 10 were the result of bodily disease, like meningitis, or of local eye diseases, like high myopia and retinitis pigmentosa, with 1 case the result of traumatic asphyxia.

Of the totally blind, 17 had both eyes enucleated. It is probable that in the majority of cases which are reported as having both eyes enucleated an evisceration was done and not an enucleation.

Among the blind were 11 cases in which one eye had a traumatic cataract.

THE CARE OF THE BLIND AND NEARLY BLIND.

The very first of these cases received some measure of intelligent care from the ministrations of workers for the blind who had already been drawn to France to help the blind soldiers of the French Army.

By those in authority it was considered that the care of the blind, as their numbers were augmented by successive severe engagements, was one of the most pressing of the problems to be faced by the ophthalmic service. Believing that everything possible should be done to give these men courage, without undue and misplaced sympathy, it was at first thought possible that they might be routed to the port of embarkation and sent at once to the hospital in the United States especially prepared to receive them. In view, however, of the experience of Great Britain in handling this problem, as far as it concerned blinded Canadians and Australians, it was apparent that the immediate transfer of blinded men to this country was likely to have a disastrous mental effect. Hence it became necessary to provide means of giving these men some preliminary training in the American Expeditionary Forces to tide them over their first discouragement and to make them better able to care for themselves and appre-

ciate the fact that, while deprived of the most useful sense, they still, by the use of others, could accomplish wonders and be made useful and happy citizens. Having gained this confidence in themselves, they could then be transported to the United States with greater certainty of arriving in good condition.

At first, for a short time, in carrying out this preliminary training, the services of a worker who had rendered wonderful assistance among the French blinded soldiers were made use of, and she and her assistants visited the first American blind in Paris and Savenay. Later, this work was carried on in Base Hospital 115 at Vichy. Here excellent preliminary training was given to a few blind until they were ready to go to the United States. On the giving up of this small center for the preliminary education of the blind, the work was con-

FIG. 13.—Ward for blind soldiers.

tinued at Savenay, where a much larger school had been established and where at one time 35 blind men were under instruction. With the exception of a very small number, all of our American battle blind came under the care of this service.

The chief surgeon, at the suggestion of the senior consultant in ophthalmology, cabled for eight reconstruction aides, qualified to give preliminary instruction to the blind, to be placed, on their arrival, at the disposal of the senior consultant. It was intended to send two of these aides to Savenay, two to Vichy, one to Vittel, one to Red Cross Military Hospital No. 1, in Paris, one to Bordeaux, and one to England. Though the cable was sent in August, 1918, these aides did not arrive until late in December, but there was still work for them and they were very welcome. They at once became of great help in carrying on the work.

When it became apparent early in the last drive at St. Mihiel and the Argonne that a number of blind were to come down to Savenay, it was decided to organize there a school for their preliminary instruction. This school was equipped with a sufficient supply of typewriters, Braille primers, games, and other appliances for the preliminary instruction of the blind. The largest group to be sent home, consisting of 27 blinded men, departed about December 13, 1918. All of these 27 soldiers had received from three to eight weeks' training, and all reached the United States in good condition.

The work at Savenay had a striking influence on the morale of the blind men collected there, and it is felt that it was carried on in a satisfactory manner.

The following letter from the senior consultant in ophthalmology to the chief surgeon is of interest:[1]

HEADQUARTERS MEDICAL AND SURGICAL CONSULTANTS, A. E. F.,
APO No. 731, France, 15th October, 1918.

From: Senior Consultant in Ophthalmology.
To: Chief Surgeon, through director of professional services, A. E. F.
Subject: Care of blind at Base Hospital No. 8.

1. Wish to call attention to the very satisfactory condition which has finally been obtained at Base Hospital No. 8.

2. All blinded soldiers who come here classified D are put into the eye ward and there they come into immediate personal contact with Mr. Baker, himself blind since he was 6 years old and a university graduate. He has a bed in the eye ward, so as to be continually in touch with the blind men. The atmosphere in the ward room since the arrival of this teacher has been entirely changed. A large warm room near the eye ward has been set aside and equipped for the preliminary teaching of the blind, it having been found this is absolutely necessary so that the blind soldier can regain some of his mental equilibrium before taking the trip to the States. Miss Richardson, formerly in the employ of Miss Holt and now in our employ, with the willing consent of Miss Holt, is in charge of this room and has proven herself of invaluable aid. A competent French teacher has been secured who will give these blind men a few lessons in French an hour each day. It was not intended to keep the blind at Base Hospital No. 8 any longer than a few weeks, but this is considered an absolute necessity.

3. For further care of the blind the services of Lieut. W. W. Stamm have been obtained, and he has been assigned to one of the large forward centers, so that he can personally see to the transporting of these cases, of which there are quite a number as a result of the last offensive.

4. For further care of the blind, Mr. Migel, of New York, has been made a major in the Red Cross and will shortly arrive in Paris, bringing with him eight trained teachers, who are also to be enrolled in the Red Cross.

5. With all these helpers, it is felt that the blind will receive every attention necessary.

6. Major General Ireland, Surgeon General of the Army, has been very much interested in the care of the blind, and it is requested that a copy of this communication be forwarded to him.

* * * * * * *

The young lady who had charge of the work at the school for the blind wrote a very interesting account of the activities there, from which the following extracts are quoted:

It was a month before the signing of the armistice that our train pulled out of the Gare de Lyons and I realized with a feeling of elation that we were on our way to the school for the blind. In the rack above our heads were perched two typewriters and a bundle of assorted canes. We trusted that they would remain there and not give us any unpleasant surprise.

We were told that there were not then many blind soldiers, five at the school and a few who had already returned to America. On account of a recent offensive, however, there would soon be a good many more to care for. All the blind who were scattered through various base hospitals in France were to be gathered together and sent to the base hospital at which the school for the

blind had been established, where, during the wait for transportation to America, we were to keep them occupied and give them a start in their studies. Though the men were not expected to remain more than two weeks at the school they could during that time take their first steps in learning to be blind and would be in better frame of mind for the ocean trip.

We learned of an American, blind since childhood, who had come to France to work among the blind French soldiers, but who had accepted the offer to help his compatriots and was already at the school for the blind. He could be a living proof to the soldiers that a sightless man could be independent and happy too, while those of us who had eyes could help them in other ways. Nine Red Cross workers for the blind were at that time about to start for France and might be expected soon, barring further complications.

A fund had been received to carry on the work for the blind. More typewriters had been promised, as well as Braille books and games, which would be sent to us. We had already received from an organization in Paris games, watches, reed for basketry, Braille primers, a hand loom, and many other articles adapted to the use of the blind. Apparently we would have a sufficiently large equipment for the hospital work.

By the time we had thoroughly discussed all the details of the future work and eaten lunch the day was almost done and the train drew into the station which was our destination. In times of peace it was no doubt just an ordinary French "gare," but now it was alive with American soldiers and officers.

We were soon sitting in an ambulance, in company with officers and nurses also bound for the base hospital. The ride was a short one. We climbed a hill, passed a severe looking church, then rode through a narrow and muddy street of shops and houses. Finally we reached a broad and open road which led us to the main entrance of the hospital. We descended from the ambulance and found ourselves standing in front of a large gray stone building, originally intended for a French boys' school. The fortunes of war had converted it into one of the busiest base hospitals of the A. E. F.

My first visit was to the eye ward, and there I saw a large white ward containing about 60 beds. These were arranged in two long rows, leaving an avenue down the center of the ward. Soldiers seemed to be everywhere. Some were lying quietly in bed, while others were playing cards or reading.

Suddenly some one appeared, coming rapidly down the aisle toward us. He was colored and was evidently blind. He was dressed in a long bathrobe and held a tooth brush in one hand, while in the other he held a cane, sharply tapping the foot of each iron bed as he made his way toward the washroom. His face was roguish and he called out "Allez, Allez," as a warning. There was general chuckling as the sightless boys sprang aside to clear the way.

My attention was next attracted to a small group of soldiers who were gathered about a man in "civies," whom I knew instantly must be our coworker, the American blind man. An animated conversation was going on and I joined this group and soon became acquainted with the blind man, with whom we were to work. There was a tall marine in the group, who had been blinded by gas at Belleau Woods during June, a rather delicate looking soldier (with whom I almost immediately found a bond in common because, while in Paris, I had met a very close friend of his, a boy of 17, who had been in his company and who had been blinded by shrapnel at Cantigny at the same time he had); another soldier, who could see just enough to enable him to find his way around the ward without a cane, and in a bed not far from us lay another blind boy who, besides losing his sight, had been severely wounded in the leg and was thus kept in bed.

I produced a few games which I had brought with me to the ward. The blind men carefully examined the checkerboard, with its sunken and raised squares, and the round and square checkers with a hole on one side of each to be turned upward as soon as it had earned the right to be king. There were also some wooden dominoes with raised dots instead of sunken ones, and jagged edges which could be interlocked.

Nothing, however, delighted the men so much as some watches with open dials and tiny Braille numbers indicating the hours. Fortunately, there were enough of these watches to be distributed among the men.

Returning to the ward after "chow" I suggested a walk, and this suggestion was hailed with delight, as the men had not left the ward for several days. As we walked briskly along the muddy road leading into the country our spirits ran high and we laughed and joked, and by the time we returned to the hospital we all felt stimulated and happy.

Those of us in charge of the work agreed that we must immediately find a spot where we could keep our teaching materials and give lessons to the men. It was suggested that all the beds on one side of our ward should be pushed close together, thus making a vacant place at one end of it. This corner could be converted into a veritable little playhouse by inclosing it in sheets hung from the beams. We liked the idea immensely, and the ward master was soon standing on a chair, using a hammer to good purpose. We took possession of a few extra tables and chairs, the typewriters were brought to the ward, and we were ready for action.

The next move was to encourage the blind men to come to these new quarters and receive instruction. One required no coaxing, as he had already begun the study of Braille in Paris and was quite an enthusiast. Another had taken a fancy to some Braille playing cards and was, therefore, anxious to learn the symbols so that he could play "Black Jack." Typewriting also appealed to these two men. The other two, who were about, were reluctant to do anything, but finally one became interested in dominoes and the other in typewriting, and they were soon willing pupils. Meanwhile, the youngest blind soldier still lay in his bed, indifferent to all overtures, until one day I showed him a writing board which would enable him to write his own letters. This appealed to him strongly and he soon became interested in other phases of the work as well.

Arrangements had been made to have a French teacher come to the ward two or three times a week and give lessons to the blind men. This was a source of much amusement and the pupils delighted in being called "Monsieur."

And so the days passed rapidly. We had walks and talks, lessons, games, and songs—anything to shorten the hours until a convoy should start for the States. At last, in late October, the happy day arrived. There was a hasty packing of little Red Cross bags, much excited conversation, and the five blind men turned their faces homeward.

As we went back to the ward with new duties ahead of us we had a premonition that the few blind men who had recently been brought to the school were an advance guard of many more to come, and we were not mistaken. During many weeks they came—soldiers from every front. The great majority were privates in the Infantry, but there were also men from other branches of the service and a few marines. Many were the causes of their blindness. Altogether, more than 60 men came under our care, and day by day we accustomed ourselves to this rapidly growing family.

Our gatherings in the corner of the ward had by this time become so large that we had outgrown our quarters, so we took possession of the entire end of the ward and had it boarded up into a regular room, pushing both rows of beds together more closely in order to make this possible. Three long tables, several benches, and bookshelves were made for us, and a folding table for games and two comfortable arm chairs added to our furnishings. A witty blind man named the new room the "dugout," and we all agreed that it was a bomb-proof one. As there was now danger that the blind men might bump into the new door, I selected the next to the last bed on the right side of the ward and fastened a little sleigh bell on the foot as a warning. The men in approaching the dugout naturally passed their hands along the foot bars of the beds. When they jingled the bell they knew that the dangerous door was close at hand and they moved more cautiously. Many were the fingers that passed over that little bell—fingers of divers nationalities, fingers from almost all States of the Union, fingers that had formerly been employed in a large variety of trades, clumsy fingers and slender, sensitive fingers, but all of them the fingers of American soldiers who had taken part in the World War.

During the mornings the blind men sauntered in, one by one, ready for their lessons. We had no study periods or lessons of regulation length and the men were free to come and go as they wished, though in many cases we resorted to persuasion or diplomacy in order to win over some unwilling student. Braille had become an important feature in the life of the dugout. Some men were farther advanced than others, and the result was that each man was reading a different primer or book. To some of the soldiers it was of genuine interest, and they studied it with diligence, while to others it was a regular "bête noir" and a thing to be fought against, but we tried to give all the men a start in it. We had English Braille primers in regulation sized type and some in giant type. We also made use of little wooden boards with groups of six holes in them. By putting large-headed nails in varying positions into these holes, all the letters of the Braille alphabet could be formed. These we used mostly for bed patients or for those who had particularly tough fingers. The men received instruction in writing Braille with a stylus and also by machine. One pupil had a good laugh over his first lesson on the Hall-Braille writer. "Why, this is a real blind man's machine!" he exclaimed, and this very fact seemed to amuse him, and, although he was an atrocious

speller, he soon had mastered all the letters of the alphabet and was able to write them faster than any of the others could. Many a race did the men have with these machines and the excitement was intense.

Typewriting was a more popular study than Braille and had an immediate appeal to our charges. Regulation typewriters were used and we taught the modern touch system. As a rule, the men made rapid progress and quickly familiarized themselves with the keyboard. As soon as any man became sufficiently advanced in typewriting he was asked to help in giving lessons to the newcomers. One colored man learned the whole alphabet in one day, his teacher being also blind. Another soldier wrote a letter to his mother after three days of practice. This anxiety to write letters apparently spurred the men onward.

The blind men's courage was very marked, and they always avoided anything in the nature of "sob stuff," as they called it. Whenever a new blind soldier arrived in the ward there was immediate excitement, and all the other blind men wanted to know where his bed was, so that they could go over and welcome him to our circle. On these occasions a truly wonderful spirit of helpfulness and fun showed itself in these soldiers. They almost made the newcomer feel that they enjoyed being blind. The new arrivals were besieged with calls from their blind pals and quick friendships were made. One blind man literally spent several hours a day by the bedside of a blind boy from his company and they seemed to have an unfailing source of conversation. As soon as a new blind man arrived in our ward he was much impressed by the independence of his sightless pals. If they were able to shave themselves, he might as well try, too. And why should he not feed himself, as long as the others could manage it? The newcomers quickly accustomed themselves to their surroundings and wandered around the ward with confidence. It was interesting to notice the little schemes they resorted to for recognizing their beds. Sometimes one found a twig or a piece of adhesive tape fastened to the iron bar at the foot of the bed. One man said he had no trouble in finding out where he belonged because his blankets were woolier than any of the others. Most of the men, however, found their way by counting the wooden posts which acted as supports in the ward. For instance, a man would start down on the right side of the aisle and after he had passed two posts and had counted three beds beyond he could cross over to the left side of the ward and find himself safely beside his bed. Some of the men walked very rapidly up and down the line, and there were occasional collisions, and the posts were dangerous enemies, in spite of being valuable as landmarks. One of the liveliest persons in the ward was a soldier who had lost his sight in an explosion early one morning in July while resting in a ditch. When he came to the school he at once became interested in all the activities in the ward and was ready to tackle any study or game. When some one remarked about the rapidity of his walking he replied, "Oh, well! I might as well walk fast. If I'm going to bump, I'm going to bump, and that's all there is to it."

When new patients came to the ward who were not strong enough for long walks they were taken for little strolls in the corridor. It was often necessary to teach them to let themselves be guided, as many of them pulled away and shied at sudden noises, but they all soon became good walkers and trusted themselves to our care.

Some of our happiest hours were spent in walking, and the afternoon hike became a daily occurrence. The partially sighted men in the ward were usually ready to help their less fortunate pals and act as guides, but there were times when one was obliged to do service for four men. We all assembled near the door at the end of the ward, and when each man was safely clinging to the arm of a guide our little band proceeded on its way.

Sometimes we went to the village and visited miniature French shops, overflowing with every imaginable object calculated to attract the American soldier. On these shopping tours the men were always sympathetically welcomed by the storekeepers. Special reductions were made and little presents given.

When there were no errands to be done we avoided the traffic of the village and turned our steps toward the country roads, where we could walk in comparative peace. We often stopped by the roadside and frequently played games. The blind men often formed a long line and underwent a mock inspection, after which they linked arms and walked without guides. When the man at the extreme left felt the ditch at the side of the road he would call out "pull to the right," and in a moment or two, when the right wing was in danger, some one would call out "pull to the left," and thus they kept in the road. The most popular game, however, was one in which the men had to guess each others voices. It was not a new game, but the blind soldiers had never played it, and it furnished infinite amusement. After returning to the ward most of the soldiers

were glad to lie down and rest, but some of the more energetic ones came at once to the dugout, ready for more typewriting or a few games before their evening meal. To some of the men the games seemed like hard work, but to others they were an agreeable pastime and they were valuable in developing the all-important sense of touch.

Unless there was a show to attract us to the auditorium, we spent our evenings in the dugout. There was reading aloud for an hour or more. Funny stories were enjoyed most, but sometimes there would be a timid request for something with "a little love in it." The men liked poems of adventure or an occasional instructive article from some magazine. The reading often led to interesting conversation or heated arguments among the men. They discussed life in the trenches, told witty anecdotes, or described stirring scenes. If the men were in a particularly cheerful frame of mind they sang for a while before the party came to an end.

Much could be written regarding the individual war experiences of the soldiers who came under our care, but the stories often bore a similarity to each other and can not all be recounted here.

One young corporal, however, had an unusual story. When the armistice was signed he was attending a divisional school and had every reason for believing that he would soon be returning to America in excellent condition. There yet remained the closing exercises of the school and he must take part in the hand-grenade practice, which would be the final feature. November 16, the appointed day, arrived and he stood ready with his men. In another 15 minutes his duties would be over. He threw himself into the demonstration with enthusiasm, but suddenly this young corporal was flung violently to the ground. One of his own hand grenades had exploded prematurely and in an instant had robbed him of his eyesight and both hands. He came to the school a few weeks later, escorted by a devoted friend, who was constantly by his side. These men were not assigned to our ward, but they frequently visited us in the dugout and joined us on some of our expeditions to the auditorium. The corporal quickly made friends with the other blind men, and they came to his assistance whenever they found the opportunity.

Among the many blind men who came to the school there were but two officers. They were both lieutenants, and were quartered in one of the officers' wards for about eight days. One of them had not yet found himself and seemed too downhearted to take interest in anything. He visited the dugout only a few times and seemed to prefer the quiet of his ward. The other lieutenant, however, already saw a glimmer of hope for the future, and eagerly seized upon the instruction which we offered him. He was one of the most appreciative pupils we had and showed a very courageous spirit. A few weeks after leaving the school he wrote us a letter, from which the following is quoted: "I am confident that my eye is slowly improving, but if it should be decreed that I never recover my sight there are many things to compensate me for its loss, among which are the many very, very good friends I have made since being injured and the regeneration of my faith in humanity. * * * To me the guiding hand and friendly voice at the busy street corner, in hospital, on the train, everywhere, and the knowledge that family ties, which were formerly taken as a matter of course, are really God's most precious gifts, all bring a peace and joy that I may have never known had my life continued its former course."

The Red Cross workers had been much delayed and we were still watching and waiting for their arrival. There had been a series of unfortunate delays in starting the blind soldiers on their journey to America, and they were rapidly growing more impatient and disheartened. There was marked indifference to studies, and the conversation centered almost entirely on convoys, transports, and homesickness. I sent an "S. O. S." to the headquarters of the medical and surgical consultant, asking if a friend of mine, with whom I had worked in Paris, could come to the school and help us during the hard days of waiting for a convoy. The appeal was answered, to my great relief and joy, by my friend in person.

At about this time two reconstruction aides came to the school. Both were familiar with Braille and had had considerable experience with blind people. One of them had received training in handicrafts, and she at once collected a group of men around her and taught them how to make watch fobs, clay beads, and woven belts. These novel occupations became very popular and made a pleasant change in the day's work.

The arrival of the three new workers also gave new life to our afternoon walks and the "one-eyed pilots" were no longer in such great demand.

It was not until December 19 that 27 of our soldiers were tagged, and although we knew how empty the ward would seem without them, we could not but rejoice at their long-delayed departure.

The day before Christmas we took all of the blind men, with the exception of a few bed patients, to the village for a Christmas dinner. A few presents were exchanged, but our largest and most

welcome gifts consisted of two Red Cross workers for the blind, who had at last arrived from America. The rest of the unit had been dispatched to various parts of France for the purpose of collecting isolated cases of blindness and would eventually appear, with their patients, at the school.

The holiday excitement having subsided, we resumed our lessons. The Red Cross workers had brought Corona typewriters with them, and these proved most valuable, as they could be used by the bed patients. The new teachers also had ingenious puzzles and materials for making hammocks and brushes, which gave new zest to life in the dugout.

On January 22 twelve more of the blind men left for America.

During the next few weeks two Red Cross workers appeared at the school bringing a few blind soldiers with them. These men would probably be our traveling companions on the homeward voyage. Two of them were privates who had been blinded by mustard gas. Another was a young soldier who had lost his sight while removing land-mines after the armistice. Another had passed through the war unscathed, but after the cessation of hostilities was accidentally blinded. A friend of his was trying to remove the detonator from a shell and an explosion resulted.

March 2 was a red letter day. We heard that a convoy would leave the following afternoon for Brest and that our names were on the list. And so, on March 3, we started with the last of the blind men for America.

OPHTHALMIC DISTURBANCES DUE TO THE WAR GASES.

The most striking new development of the war as regards the field of the opthalmologist was the effect on the eyes of certain of the poisonous gases used by the Germans, especially the so-called mustard gas. The nearest approach seen in civilian practice to the clinical and pathological findings resulting from exposure to these war gases had been in lesions following burns by ammonia, lime, and other caustics. A most comprehensive study of the occular manifestations following exposure to poisonous gases was made by one of the ophthalmic consultants.[2] In view of the careful work done by this officer several quotations from his review are included in this section as they conform entirely with the views of other ophthalmic officers, especially with regard to the effects of bandaging.

There was necessarily much hospitalization of men with the ocular lesions of gas poisoning, and in some instances this hospitalization seemed unduly prolonged. A neurotic element was present in many of these patients and they would remain in hospital for a longer period of time than the actual eye lesions warranted complaining of intense photophobia and even of inability to open the eyes. In such cases measures of suggestion often effected a prompt recovery. In some instances patients were detected who had kept active the conjunctival irritation by vigorous rubbing of the eyes that they might remain in the hospital for a longer period.

The value of special gas hospitals was well exemplified during the period of active hostilities. When possible, specially trained nurses and orderlies were assigned to these hospitals under the direction of an experienced ophthalmologist to care for the patients with eye involvements. Special provisions were made for the treatment of these conditions at the first-aid and dressing stations, as the final results were often dependent on the care given these patients promptly after the initial exposure. An impression gained considerable ground that the effects of mustard gas on the eyes were slight and transitory, but the fact that three soldiers were rendered almost totally blind by this agent, and in five others the injuries resulted in partial (industrial) blindness, must cause this condition to be regarded as one of utmost seriousness.

The following extracts from a series of 106 autopsy protocols of men dying from the effects of poisonous gases show the marked ocular involvement in many cases:[3]

CASE 5.—Mustard: Cloudiness of cornea and conjunctivæ.

CASE 7.—Mustard: Burns of conjunctivæ and cornea.

CASE 9.—Mustard: There is purulent conjunctivitis.

CASE 12.—Mustard and chlorpicrin: Burns of conjunctivæ and cornea.

CASE 16.—Mustard: The eyelids are somewhat swollen, the lids glued together by tenacious mucopurulent material; the conjunctivæ edematous; and there are patches of injection of the bulbar conjunctivæ. There is a slight cloudiness of the cornea.

CASE 17.—Mustard: Purulent discharge from eyes.

CASE 18.—Mustard: Burns of conjunctivæ and cornea.

CASE 19.—Mustard: Conjunctivæ are injected.

CASE 20.—Mustard: The conjunctivæ are diffusely injected; there is a small amount of fibrinopurulent secretion present; both corneæ are cloudy.

CASE 22.—Mustard: Eyes showed conjunctivitis; bilateral keratitis, corneæ had steamed appearance.

CASE 24.—Mustard: The epidermis about the eyes and conjunctivæ are rough and reddened and covered on the left side by an exudate.

CASE 25.—Mustard: Eyelids puffy and glued together by tenacious viscid exudate. The conjunctivæ edematous and injected.

CASE 26.—Mustard: Extensive burns of conjunctivæ and cornea.

CASE 27.—Mustard: Eyelids matted together by a small amount of mucopurulent exudate. The conjunctivæ edematous, injected. Small hemorrhages below the bulbar conjunctivæ. The cornea slightly clouded on both sides.

CASE 28.—Mustard: Conjunctivæ markedly injected, corners of eyes stuck together by dried exudate.

CASE 31.—Mustard: Eyelids puffy, matted together by tenacious mucopurulent secretion. The conjunctivæ somewhat injected and there were small hemorrhages. The corneæ were somewhat cloudy, especially the left.

CASE 32.—Mustard (?): Eyes, bulbar and palpebral conjunctivæ irregularly injected with small hemorrhages here and there. Gluing the eyelids together was considerable caked exudate.

CASE 33.—Mustard: Superficial burns of conjunctivæ.

CASE 34.—Mustard: Burns of conjunctivæ and cornea.

CASE 35.—Mustard: Dried blood tinged exudate in the corners of the eyelids, evidence of recent conjunctival inflammation, several small ecchymoses in the bulbar and palpebral conjunctivæ.

CASE 36.—Mustard: The eyelids somewhat puffy, conjunctivæ edematous, deeply injected. Small hemorrhages. Between the lids there was a small amount of caked mucopurulent material.

CASE 38.—Mustard: Eyelids somewhat puffy, conjunctivæ deeply injected. Between lids there was a small amount of caked mucopurulent secretion.

CASE 42.—Mustard: Conjunctivitis with keratitis of both eyes. Burns of lower eyelids.

CASE 44.—Mustard: There was a dusky, purple discoloration about eyes. Lids of each showed some desquamation of epidermis and marked injection and hemorrhagic inflammation of conjunctivæ.

CASE 47.—Mustard: With both conjunctivæ considerably injected and over the left cornea there was a wedge-shaped area of grayish thickening a few millimeters in diameter. Eyelids somewhat puffy.

CASE 51.—Mustard: Eyelids edematous. A marked amount of mucopurulent exudate between lids. Conjunctivæ injected with small dark red hemorrhages.

CASE 52.—Mustard: Slight involvement of the eyes, especially the left. Conjunctivæ on this side moderately injected. Cornea showed slightly milky thickening.

CASE 53.—Mustard: Bulbar and conjunctivæ somewhat swollen; patchy injection, and on left side particularly there were deep red hemorrhages below conjunctivæ. Lids puffed and glued together by exudate.

CASE 56.—Mustard: In skin of both upper lids there were a few superficial ulcerated areas covered by reddish-brown scabs. The bulbar conjunctivæ were somewhat edematous; consider-

ably injected. There were scattered small deep red hemorrhages. Over the cornea was a small amount of mucopurulent exudate.

CASE 57.—Mustard: Conjunctivæ of both sides bulbar and palpebral injected; marked on the right. Eyelids of both sides glued together by viscid and caked exudate. Most marked on the right side. There were small hemorrhages below the cornea on the right side.

CASE 58.—Mustard: Eyes showed intense conjunctival edema, with several fresh hemorrhages beneath bulbar conjunctivæ.

CASE 62.—Mustard: Outer corners of the eyes were glued together with matted exudate.

CASE 67.—Doubtful gas: Desquamation of epidermis. Dusky pigmentation and congestion about eyes; dried exudate in the corners; deeply injected conjunctivæ; evidences of recent inflammation.

CASE 70.—Mustard: Superficial burns of eye, conjunctivæ, and cornea.

CASE 71.—Mustard: Eyelids puffed. Lids glued together by caked exudate. Conjunctivæ injected. There are small hemorrhages. Both corneæ somewhat transparent.

CASE 81.—Mustard: Eyelids slightly swollen. Conjunctivæ somewhat edematous and the bulbar portions considerably injected. On the left there are in addition a number of scattered small red hemorrhages.

CASE 85.—Mustard: Conjunctivæ somewhat edematous; considerably injected. There is a small amount of viscid exudate present between lids.

CASE 88.—Mustard: Conjunctivæ in general pale and delicate. There is some swelling of the bulbar conjunctivæ and an amount of caked exudate present.

It will be seen that there were conjunctival burns noted in 39 cases of this series and in 17 of these the corneæ were involved. To what extent the use of gas masks lowered the incidence and severity of the conjunctival and corneal involvement in these cases can not even be surmised. It was noted many times in the gas service, however, that men who had bad body burns did not have ocular manifestations until the masks were removed, after which the eyes were infected by the hands or clothing.

Infection of the conjunctiva may occur, especially when the eyes have been bandaged; then secondary infection of the cornea may take place, resulting in ulceration and, later, even panophthalmitis with loss of the eye. Fortunately, such cases are rare.

CLINICAL EFFECTS OF GASES ON THE EYES AND ANNEXA.

From a published report by a medical officer the following observations are given: [2]

Lacrymatory gas caused intense burning pain, profuse lacrymation, and injection of the conjunctiva. The eyes of men who had been in contact with this type of gas showed marked photophobia and watering, the palpebral borders were swollen and showed erythematous lesions, which followed rubbing with the hand or the handkerchief. There were marked conjunctival injection and occasional chemosis. According to Gremaux [a], the cornea presented in its peripheral portion a fine exfoliation of the epithelial covering. The milder cases recovered very quickly and the corneal lesions showed no tendency to extend. The more severe cases were usually well within two weeks, or then only showed a slight photophobia and watering, which disappeared at the end of three weeks or a month. The reaction was always more severe when a bandage had been used on the eye.

Mustard gas causes sneezing, followed by increasing nose and throat irritation. There is a painful irritation of the eyes and sometimes vomiting. The action is a delayed one, and takes place in from two to six hours with increasing inflammation of the mucous membrane and the skin.

All grades of mustard gas involvement of the eyes may be met with. They may be divided into slight, moderate, and severe. The slight cases form 75 per cent or 80 per cent of those affected. Often in mild cases the subjective symptoms are severe. The lids are held tightly closed. There is a profuse lacrymation and a considerable degree of injection of the conjunctiva.

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[a] *Progrès médical*, 1916, 157.

LATE MUSTARD-GAS CONJUNCTIVITIS (16 DAYS AFTER GASSING).

In those more severely affected the lids always show a considerable amount of redness and swelling and often the formation of numerous bullae. The lid margins are sometimes excoriated. The lids are held closely pressed together, and any attempt to separate them is accompanied by severe pain, so that often it is necessary to use one or two drops of cocaine (holocaine is better) and employ a lid elevator to get a good view of the conjunctiva and cornea. The conjunctiva is markedly injected throughout, and may show a considerable degree of chemosis, which is most marked in the upper and lower conjunctival folds, which may project beyond the lids. Often the injection is of the distinct ciliary type. The region of the palpebral fissure is the most severely affected. In severely burned cases there is often an area of solid white edema of the conjunctiva in the palpebral fissure, which presents a very striking appearance. This is, perhaps, the most characteristic appearance. The edema is pyramidal in shape with base to the cornea on each side. The greatest edema is near the limbus and gradually diminishes toward the apices of the pyramids at the canthi. (Plate V–B, facing p. 694.)

The corneal lesions are also of varying severity. In the milder cases there is only a very slight roughing of the corneal epithelium which may or may not stain with fluorescin. In the moderately severe cases there is a marked roughening of the epithelium with irregular grayish areas of opacity scattered throughout the cornea. The extent of the corneal lesions depended largely on the amount of the circumcorneal edema and the necrosis of tissue which followed.

In the most severe cases a very saturated gray band is seen traversing the cornea in the area of the palpebral fissue and this band is sometimes of almost porcelain whiteness. The roughening of the cornea is due to edema of the epithelium and later on to exfoliation.

Where liquid mustard gas was actually spattered into an eye (as occurred to a worker) the result was startingly severe and destructive.

TREATMENT.

The same observer[2] suggests that when the soldier receives his first bathing after exposure to mustard gas, the eyes should be thoroughly washed out. Sodium bicarbonate was found to be as good a solution as any for this purpose. It was used as a routine in our gas hospitals, of which we had several in the areas back of the Argonne.

To obtain the greatest measure of success in their treatment, these cases had to be taken care of as quickly and thoroughly as possible. The less time lost between the gassing of the eyes and the treatment the better the ultimate result. It was imperative that those who first came in contact with the gassed soldiers should understand the necessity of immediate and proper treatment. The instruction of those giving first aid was carried on in France, a thoroughly qualified ophthalmologist was placed in each of the gas hospitals, and many of the regimental surgeons were given counsel and instruction. During the latter part of the Argonne offensive the results of early treatment were most gratifying.

The report quoted above continues:[2]

In the later stages, when the soldier is sent back to the evacuation hospital or the base hospital frequent bathing should be given him with a lukewarm solution either of boric acid, salt solution of 1 per cent sodium bicarbonate. Following this, a drop of oil should be instilled into the eye. The oil which was found the least irritating was liquid albolene. Theoretically, a vegetable oil, such as castor oil, should prove to be of value, as it dissolves the mustard gas. In practice, however, we found it rather more irritating than the liquid albolene and gave it up. For the milder cases this treatment will suffice.

When, however, there is much blepharospasm and irritation, atropine should always be used, for this indicates a greater or less involvement of the cornea. If a 1 per cent solution of atropine is used once or twice a day, it will usually keep the pupil well dilated. Occasionally, however, one must use it in larger amounts. A shade should always be supplied or a pair of dark glasses. The eyes should never be bandaged. Agreement on this point is unanimous. In the British service and in our own a great deal of trouble was experienced from the bandaging of these cases.

In a number of cases where secondary infection of the cornea took place and the vision was permanently impaired or the eye was even lost, we felt very strongly that bandaging contributed materially, if not entirely, to the bad results.

In those cases where secondary infection of the conjunctival sac took place a weak antiseptic solution was found to be of benefit. Most often we used argyrol or protargol. If an actual septic ulcer of the cornea developed, it was treated by the methods used in civil life. As the nutrition of the cornea is impaired, it is well to apply heat when corneal ulceration occurs. The ulcer may be lightly touched with pure carbolic acid, and if necessary a Saemisch section may be made.

Atropine should be continued so long as any corneal involvement in gas cases continues, and a shade or dark glasses should be worn as long as the pupil is dilated. As soon, however, as the pupil has resumed its normal size and the injection has largely disappeared, the patient, if his general condition permits, should be gotten out of his bed and should be sent outdoors into the light, and stimulating treatment should be applied if subjective photophobia and lacrymation still persist. Cold bathing of the eyes seems to be of value and a weak solution of sulphate of zinc twice a day. It is always wise to give the patient in this stage some sort of light duty. One should be always on the watch to combat the beginning of a neurasthenic tendency. These patients always recover with normal vision, unless a severe involvement of the cornea has taken place. In the treatment of gassed eyes cocaine should not be used, as it tends to damage further the corneal epithelium.

Realizing that the results of mustard gas injuries of the eyes were of a serious nature the ophthalmic consultants issued the following circular to all medical officers:[4]

Gassed eyes.—Treatment of eyes injured by those gases which produce a chronic conjunctivitis (mustard gas—dichlorethylsulphide):

The earliest possible treatment is necessary to lessen the duration of the disability. The early treatment should be given at the first bathing. It should consist of a thorough flushing of the conjunctival sacs with a 1 per cent solution of sodium bicarbonate, preferably warmed to body temperature. Care should be exercised to see that both the upper and lower cul-de-sacs be thoroughly cleansed.

Following this treatment the eyes should be washed out every four hours in severe cases, with either solution sodium bicarbonate, 1 per cent, normal saline solution, or a saturated solution of boric acid, and a drop of liquid albolene should be instilled after each washing. Olive oil may be used when liquid albolene is not available.

In the more severe cases corneal involvement of greater or less degree is common. This takes the form of a roughening and opacification of the corneal epithelium in the area of the palpebral fissure. Infection through this sodden epithelium may take place, leading to ulceration, and produce permanent damage to the eye, and may even cause a complete loss of sight. Such cases always show marked photophobia and usually a contracted pupil.

In such cases a solution of atropine sulphate, 1 per cent, should be used sufficiently often to keep the pupil dilated, and the eyes should be shaded from the light but never bandaged. As soon as the corneal or uveal disturbance has subsided the atropine should be discontinued, and it is advisable to get the patient up and accustom him to the light to avoid long hospitalization of such cases. Secondary infection of the conjunctiva is common and may be treated by a solution of argyrol, 20 per cent, instilled three of four times a day. Self-induced relapses are not uncommon and should be watched for.

In the later stages, when photophobia persists without signs of conjunctival irritation to account for it, it is advisable to use cold douching of the eyes two or three times a day and to employ the patient in some suitable light occupation.

Where corneal involvement is marked, the ophthalmic consultant should be asked to see the case.

OCULAR MANIFESTATIONS OF INTRACRANIAL INJURIES.

The ophthalmic consultants who had served with the British were much impressed with the importance of examining the eyes of soldiers with head injuries early and often and urged the ophthlamic surgeons in the American Expeditionary Forces to watch all such cases carefully. In Circular No. 1,[4] under brain injuries, instructions were given that all brain injuries or severe

cranial wounds likely to show brain involvements should be frequently examined by the ophthalmic surgeons, and all opportunities should be improved for studying the fundi and fields of vision in such cases. The information thus gained was of great scientific value as well as of assistance to the neurosurgeons in diagnosing and treating injuries of this type.

The important manifestations to look for were changes in the discs, ocular palsies, and field defects. The changes in the discs varied from slight blurring with engorgement of the veins to a severe choking, with an elevation ranging from slight to four or five diopters. Two causes for the disc changes could be ascribed. The first, and much the more common, was increased intracranial pressure; the second was meningitis. The first simply resulted in a less or greater degree of swelling, while the second caused an inflammatory swelling, with the inflammation extending outward from the disc, resembling a neuro-retinitis. In cases of cerebrospinal meningitis this inflammation often resulted in subsequent atrophy; in a few cases the inflammation extended to the choroid and was virulent enough to result in a suppurative choroiditis, followed by entire loss of the eye.

The neurologists and head surgeons with the American Expeditionary Forces were well aware of the importance of these examinations, as it had been thoroughly demonstrated that a rapidly increasing choking of the optic discs signified the necessity of a decompression operation or the removal of disorganized brain material, blood clots, or pieces of shell. A large number of such cases occurred in the hospitals of the American Expeditionary Forces.

An officer who was stationed at one of the hospital centers as a consultant reported intraocular studies of 59 cases,[5] varying from comparatively slight contusions and scalp wounds to those in which there was extensive loss of skull and brain substance. Of these 59 cases, 20 showed definite changes in the disc. In 3 cases magnetic foreign bodies were removed, in 2 of them from the brain substance; in at least 4 cases there was positive evidence of brain abscess, and 2 developed basilar meningitis, in neither of which were the intraocular changes at all marked, due, no doubt, to the large traumatic decompression present in both cases. Three were recent fractures occurring in the hospital area, none of which developed intraocular changes.

The following case reports are of interest:

Case 24.—H. E., mechanic, sustained a gunshot wound 2 inches back of the left ear. Examination October 2, 1918, presumably 48 hours after the injury, showed a very slight blurring of both discs, retinal veins not engorged, pupil reflexes normal, but a complaint of slight haziness of vision. Examination the following day showed slight increase of symptoms, discs now distinctly blurred, vessels slightly engorged, pulse 55, no other evidence of intracranial pressure. On October 4, discs showed an elevation of one diopter, with a pulse of 60. On October 8 there was a decided improvement in the intraocular condition and his general condition was better, while on the 14th, 12 days after the first examination discs were normal and the general condition of the patient was entirely satisfactory.

Case 25.—Pvt. W. M., examined September 19, 1918; was taken directly from the ambulance to the operating pavilion approximately 24 hours after injury. An irregular foreign body, 2 or 3 centimeters below the vertex in the right brain, was shown by the X ray. Ophthalmoscopic examinations on the operating table showed the pupils small, marked blurring of the right disc, vessels engorged, slight elevation, left disc blurry but not elevated. Under local anesthesia, the scalp wound was cleansed, skull wound enlarged and a fragment of shrapnel removed from the brain substance by means of a Lancaster portable magnet, the tip being supplemented by a short steel rod which was first passed down to the region of the foreign body and held against the tip of

the magnet while the current was turned on. On the following day there was a preceptible improvement in the condition of both discs, and they were practically normal at the end of ten days.

CASE 26.—Pvt. P. B., presented a scalp wound near the vertex which he had received approximately two days before examination, September 20, 1918, but the X ray showed neither a foreign body nor any perceptible splintering of the inner table. The patient's vision was apparently normal, while his mentality was decidedly below normal. There was a blurring of both discs with an elevation of one diopter or less. He was examined daily for five days, and as there was a gradual increase in the amount of the disc elevation, the surgeon in charge decided to do a decompression operation. Under local anesthesia, the scalp wound was reopened and a slightly depressed fracture of skull exposed. The depressed skull fragments were elevated and a few fine superficial bone splinters removed from the dura. There was no shock following the operation, the intraocular symptoms subsided promptly, the mental blurring disappeared, and the patient made an uneventful recovery.

CASE 27.—October 3, 1918, by request of the department of surgery, the fundus of Corporal S., who had been under treatment for several days for a badly infected vertex wound, was examined. There was a large destruction of the bony tissue, with exposure of the brain substance. Patient complained of some headache and was rather drowsy. The right lids were puffy, the pupils reacted normally while the disc edges were blurry and the vessels engorged with slight elevation. In spite of the large skull defect and apparent free drainage, there was a gradual increase of the papillary edema until, just before death, October 23, it reached a height of six diopters in the right eye and five in the left. Rather numerous subhyaloid hemorrhages had appeared three or four days earlier. The patient complained of intense headache, but as there were no other symptoms of brain abscess and the adjacent portions of the brain were draining so freely, the surgical department hesitated to explore the deeper structures despite the ocular picture. About fifteen hours before death there was a hernia of brain substance, followed by relief from pain. Autopsy disclosed a large abscess in, or in the region of, the right lateral ventricle, which evidently by its rapid progress and local pressure produced the marked ocular symptoms.

CASE 28.—Pvt. X. was injured the first day of the St. Mihiel drive. A fragment of shell punctured the skull 2 inches above the left ear and lodged, as the X ray showed, to the left of the median line, on a level with and 1 cm. back of the sella. He had complete aphasia, and was practically unconscious. The right leg, arm, and hand were partially paralyzed and the deep reflexes diminished. On September 19 his condition was unchanged; pulse about 60. On September 20 the foreign body was removed and the next day he improved considerably. The reflexes returned, only to last a few days, and then gradually disappeared. The fundi were examined. The pupillary reflexes were slow until the 24th, with slight blurring of the right disc. On the 26th the left disc was also involved, increasing until the 28th, when the man died. The autopsy showed a few fragments of bone in the tract of the foreign body, with an abscess at the end of the tract.

Fractures of the skull involving the base frequently gave rise to paralysis of the nerves supplying the ocular muscles, particularly the sixth nerve.

The ocular manifestations of intracranial injuries, however, which aroused the most interest among ophthalmic surgeons in the war zone were changes in the visual fields produced by injuries to the posterior occipital lobe or lobes. By knowing the exact location of small losses of brain function and the consequent defects in the visual fields, a knowledge of the location of the visual centers for various portions of the retina was obtained more exactly than ever before. The work of two English observers, Lister and Holmes, was especially noteworthy along this line. In general it can be said that in the portion of the brain just above the calcerine fissure were located the centers receiving nerve elements from the upper portion of the retina. A destruction of the brain in this region, therefore, would give a homonymous sector defect in the lower fields on the side opposite to the brain injury. If this area on both sides of the brain was destroyed by some transverse injury, like a bullet wound across the occipital region high up, the field defect would be one of altitudinal hemianospia rather than a homonymous sector defect. The following cases are of interest in this connection.

CASE 29.—Corpl. T. M., with diagnosis of gunshot wound, occipital region and back, severe, on September 6, 1918, entered base hospital on September 15, 1918. X-ray report: Perforating fracture of occipital portion of skull, with several éclats in brain substance. The éclats lay in occipital lobes of brain and in the brain substance posterior to the fissure of Rolando. Ophthalmological report: Ocular rotations full, pupils equal, regular, and responded to reflexes. O. D. media clear, disc hyperemic, margins hazed, veins engorded and tortuous. No hemorrhages. Vision O. D., doubtful light perception; O. S. similar to O. D. Vision O. S.; counted fingers at half meter in upper field. Diagnosis: Beginning papillitis. September 19, increased haziness of disc margins, with marked edema of retina adjoining disc above. Increased engorgement and tortuosity of veins. O. S. similar—less marked edema of retina. September 24, no change. September 29, operation. Curved incision over occipital region and flap reflected. Brain pulsating slightly and cerebrospinal fluid flowing from middle of hernia. Opening enlarged in dura, some small fragments of bone and several éclats removed. October 15, general condition good. Counted fingers in both upper fields. Papillitis subsiding. December 1, wound healed. Condition good. Disc good color, margins fairly well defined, no edema of retina, vessels practically normal. V. O. D. 20/70, V. O. S. 20/70. Fields of vision are shown in Figure 14.

The portion of the posterior occipital lobe below the calcerine fissure conversely received nerve elements from the lower half of the retina and in-

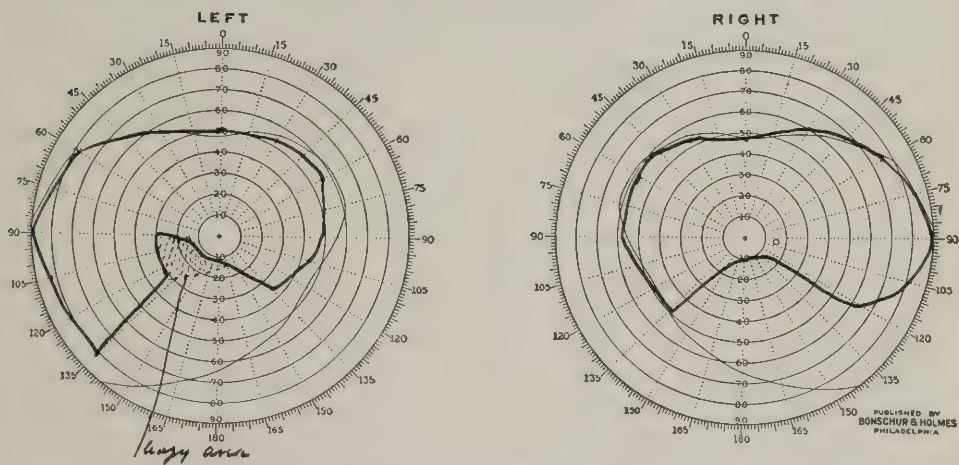

FIG. 14.—Case 29: Fields of vision.

juries here caused corresponding field defects. If, as could happen, an injury was so extensive to the occipital region as to cause destruction of most of the brain tissue above and below the calcerine fissure on both sides, then the patient, if he survived, would be practically blind. (See Case No. 53 in the list of blind.)

CASE 30.—H. A. K. Diagnosis: Gunshot wound, occipital region, October 8, 1918. X-ray report: Several small foreign bodies under wound within skull. Neurological report negative. Eye examination: Ocular movements normal, pupils equal, regular, and respond normally. No fundus changes. Complained of seeing only parts of objects. Fields roughly taken were apparently full. Operation: Wound excised, skull trephined, and foreign body and several small pieces of bone removed. Dural opening enlarged and tract washed out through soft catheter. Pulsation of brain noted. Dura left open. Wound closed with drain. November 2, 1918: Nasal portion of each disc blurred, veins overfull. No other changes. Patient in good condition. November 25, 1918: Nasal margins blurred. Fields taken showed absolute scotoma near point of fixation in both eyes. Fields of vision are shown in Figure 15.

CASE 31.—E. A. D. Diagnosis: Gunshot wound (high explosive) of head, compound comminuted fracture of occipital bone August 29, 1918. Operated on at field hospital August 31. Admitted to base hospital September 1, 1918. September 3, 1918: Ocular rotations full, pupils equal and responded to reflexes. Ophthalmoscope: Media clear, disc hyperemic, all margins

hazed, veins dark, engorged, and tortuous. No hemorrhages or exudates. Temperature 101.7, pulse 72. September 9, 1918: Patient apathetic and indifferent. Pulse 56. Complained of slight but continuous occipital headache. Ophthalmoscope: Both discs showed choking of 4 diopters. Vessels as before. Ocular rotations full. Fields roughly taken showed a right homonymous hemianopsia. Neurological examination negative except a slight asteriognosis of right hand. Conclusion: There was an involvement of left occipital lobe near the area striata. September 13: General condition improved. Asteriognosis better. Papilledema subsiding, 2 diopters. Advised against further operation at that time. September 30: Patient continued to improve. Papilledema had practically disappeared. Disc margins still a little hazed. Complained of inability to see to the

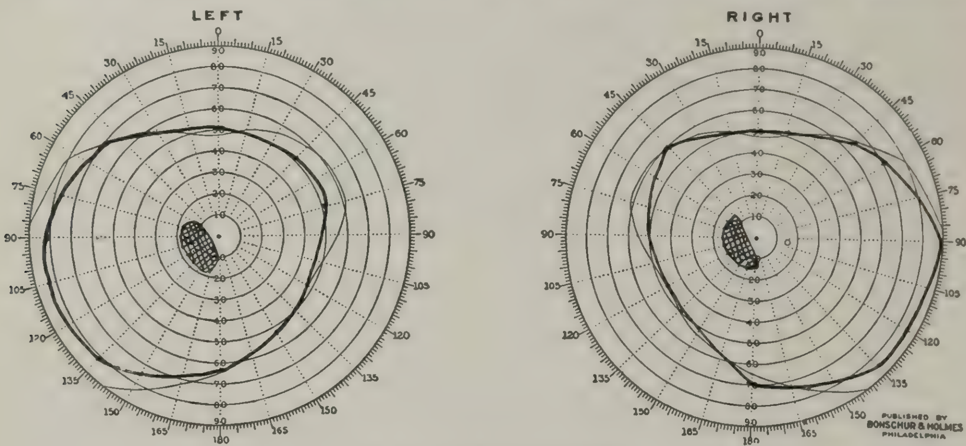

Fig. 15.—Case 30: Fields of vision.

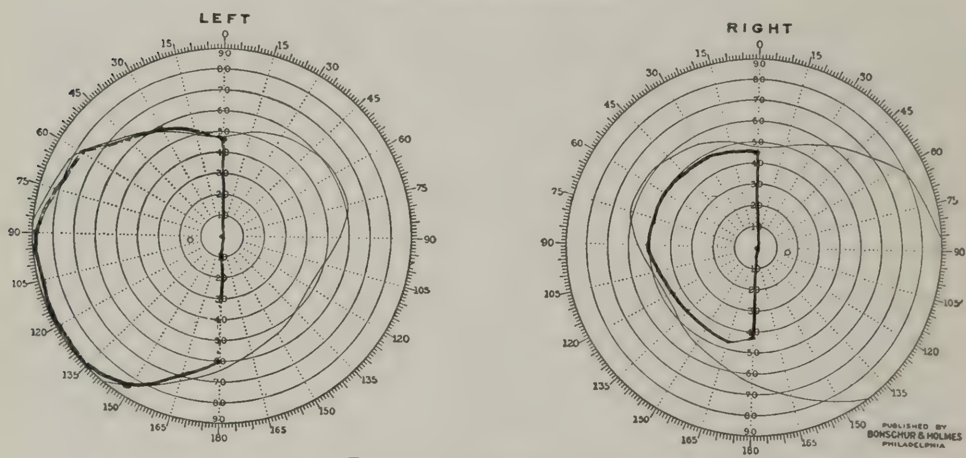

Fig. 16.—Case 31: Fields of vision.

right. October 15: Patient continued to improve. October 25: Patient apparently normal. Discs good color, margins slightly feathery. Fields showed a right homonymous hemianopsia, central vision not involved. Fields of vision are shown in Figure 16.

Case 32.—F. B. On November 1, 1918, while operating a machine gun on the Argonne front, was struck in the right occipitoparietal region by a fragment of high-explosive shell. Did not become unconscious for 45 minutes. Helped dress the wounds of his companions and then fainted. Was unconscious about three days. Was operated upon at a mobile hospital on day of injury and portion of skull removed. This patient, as shown by his chart, finally had a left hemianopsia, complete except for about 5° around the macula. (Fig. 17.)

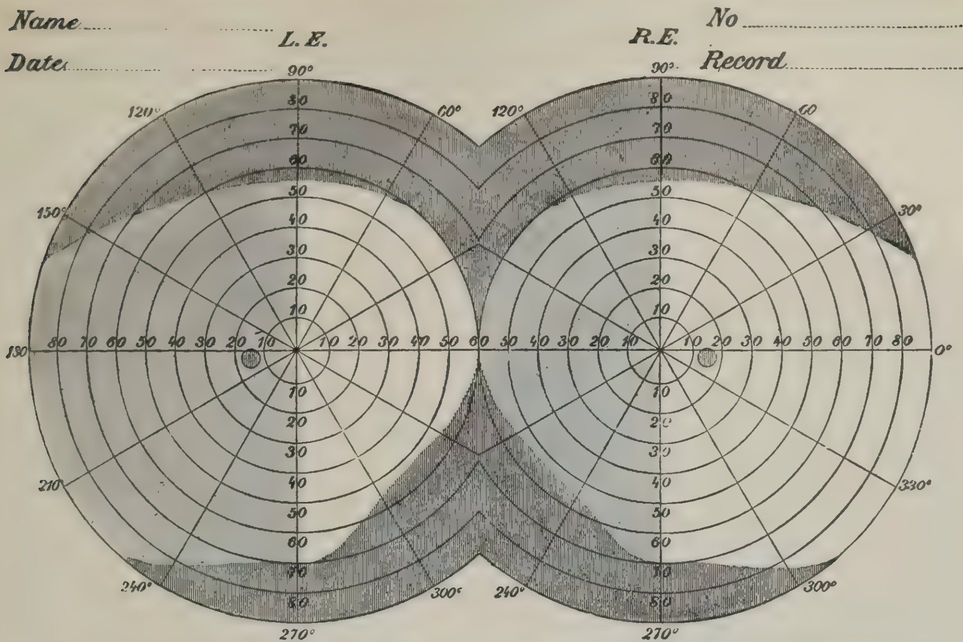

FIG. 17.—Case 32: Showing left hemianopsia complete, except for about five degrees around the macula.

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CHAPTER III.

OPHTHALMIC UNITS.

SPECIAL HOSPITAL FOR HEAD INJURIES.

Shortly after the declaration of war a plan was suggested to the Surgeon General by which one of the base hospitals would be especially organized and equipped for the exclusive care of injuries and diseases of the eyes and ears. The importance of such an undertaking was promptly appreciated, and certain officers were designated to prepare an outline for the organization of this hospital. After a thorough consideration of all the requisite details of a hospital of this character, it was decided to broaden the scope of the institution as originally contemplated and to afford provision for the care of all injuries and diseases involving the head, brain, face, eyes, ears, nose, and throat. The capacity was to be 1,000 beds and the organization was usually referred to as the head hospital. Elaborate plans for the construction of the necessary buildings to accommodate this hospital had been prepared but these were discarded when information was received from France that the hospital would probably be located in one of the buildings which had already been taken over for use as a hospital.

The organization of the hospital contemplated the establishment of four services, namely; ophthalmology, otolaryngology, brain surgery, and oral and plastic (maxillofacial) surgery, each under the direction of a chief, with the necessary assistants. Included originally as a part of the ophthalmological service were optical units, but, owing to the necessity of sending these units abroad before the rest of the hospital sailed, this section was released from the personnel of this special hospital.

In addition to the specialists mentioned above, the personnel of this hospital was similar to that authorized for other base hospitals.

In accordance with these plans, Base Hospital No. 115, the special "head hospital" was mobilized at General Hospital No. 11, Cape May, N. J., and, embarking in August, 1918, arrived in France on September 2.[1] This unit was assigned to station in Vichy and immediately began to function in buildings allotted to it.

Plans for the routine transfer of special cases to this hospital were formulated and instructions to this end were issued in Circular No. 50, Office of the Chief Surgeon, American Expeditionary Forces, which read as follows:[2]

1. *Instructions regarding hospitalization and evacuation of patients with disease or injury of the eye, ear, nose, throat, and maxillofacial region.*—In general, the policy as regards hospitalization and evacuation of these cases is as follows:

(*a*) Simple cases should, whenever possible, be retained for treatment with their organization or be treated in near-by camp, field, or evacuation hospital.

(*b*) Cases not suitable to be retained with organizations but which will be fit for return to duty in the A.E.F. within a reasonable time should be transferred to the nearest camp or base hospital.

(*c*) Cases which are permanently unfit for duty in the A.E.F. or which will require prolonged treatment to render them fit for duty should be classified as "D" and evacuated as soon as safely transportable to the United States. Class "D" cases in which healing might be materially retarded

by delay or interruption of treatment incident to evacuation to the United States, or which have unsightly wounds of the face and neck that could be materially helped, within a reasonable time, should be retained for primary treatment in the A.E.F.

The treatment of cases retained in France must involve the least possible amount of transportation from one hospital to another, and facilities will be provided in each hospital center and in the larger base hospitals not connected with hospital centers for the treatment of this class of cases. Base Hospital No. 115, located at Vichy, has more elaborate equipment for this class of cases.

Consultants in the different specialties will be located in certain hospitals, whose services can be called upon by neighboring hospitals. Address where those consultants can be reached will be published from time to time.

2. *Ophthalmic cases.*—Routine refractions and vision examinations for troops should be done in the nearest hospital serving these troops. Ophthalmic cases which require more elaborate treatment than can be given in isolated camps or base hospitals and which do not come within the provisions of paragraph 1 (*c*) above, should be transferred to the nearest hospital center, or upon recommendation of the local or senior consultant in ophthalmology be transferred to the Base Hospital No. 115, Vichy.

It was also planned to make this hospital the teaching center for officers who needed more advanced instruction in their specialties, and a number of medical officers were sent there for that purpose.

A very creditable ophthalmic clinic was built up, and had the war continued a vast amount of material would have been handled. Enough was accomplished in a short time, however, to more than justify the organization of the special hospital for surgery of the head.

OPTICAL UNITS.

The preliminary steps looking to the formation of as well as the actual organization of optical units have been described in the administrative history of the Division of Head Surgery, Office of the Surgeon General, in Volume I of this history.

On May 4, 1918, the first organization of this character, consisting of a base optical unit and eight auxiliary units, arrived in France.

The equipment, stock, and machinery for the shop to be established by the base unit had been shipped from the United States before the departure of the unit, but on the arrival of the unit in France the machinery could not be located. Part of it, however, reached Paris on July 4, 1918. The result of this delay was that the personnel of the base unit was partially idle for nearly two months; and this delay in getting to work prevented the sending of replacement lenses to the eight auxiliary units which were sent out shortly after their arrival in France. This lack of replacement lenses was never fully made up.

While awaiting the machinery, facilities were afforded for a number of the members of the base unit to work in an optical shop in Paris grinding lenses for the A.E.F. The remainder of the machinery arrived in Paris, September 29, 1918.[3]

The building for the shop was completed July 24, 1918, and was located first at Neuilly, with the instrument repair shop, later being moved to Porte St. Cloud to be with the medical department repair shop. The shop was partially in operation July 27, 1918, but not in full operation until October 1, 1918. The machinery and equipment supplied was based on an approximate production of 100 pairs of glasses per day.[3]

From July 27, 1918, to December 1, 1918, the production was as follows: 21,828 prescription jobs, 3,091 smoked spectacles, 1,620 repair jobs. The unusual nature of the prescriptions received caused many complications, necessitating the manufacture of special tools and gauges. Prescriptions for spherical lenses as high as 12.00 D and cylindrical lenses as high as 10.00 D were received and filled. Fifty per cent of the prescriptions received averaged spherical from 2.00 to 5.00 D., in combination with cylinders from 1.50 to 5.00 D.[3]

The equipment of the shop was:

7 hand surface grinding machines.	1 diamond drill.
4 automatic cylinder grinding machines.	1 diamond cutter.
6 automatic edge grinding machines.	3 pairs spherical grinding tools.
3 hand edge grinding machines.	29 pairs toric cylinder grinding tools.

There was also a complete small tool outfit, such as buffs, centering machines, neutralizing instruments, files and pliers.[3]

The surface grinding machinery was not designed for the unexpected amount and unusual character of work received. Rough cylinder blanks for optical machinery were not available in France. To produce these lenses from rough glass stock with the limited number of cylinder machines designed for special work was slow and unsatisfactory even with a full day and night force in operation.

A special attachment was devised to supply the demand for prescription lenses in gas masks. This attachment fastened over the eye cups of the masks and contained a 47 mm. lens so decentered as to give the proper pupillary distance.

Nearly a thousand prescriptions for glasses came into the shop prior to the setting up of the machinery, and there was a steadily increasing flow of prescriptions, taxing the personnel to the utmost. At the time of the armistice the base optical unit had sufficient machinery and men to care for the prescription and repair work of the entire American Expeditionary Forces, but, owing to the slowness with which the supplies had come to hand it had never been possible to take full advantage of the facilities, and at that time it was particularly embarrassing, owing to the failure of six auxiliary units, which had recently arrived in France, to bring their supplies with them, as directed by cable. Counting on this supply, the stock at the base unit had been heavily drawn on to provide the supplies for the newly organized units sent to Mesves Center, Base Hospitals 29 and 33, and the two units sent to the army of occupation.[3]

All this entailed a great deal more surface grinding than was originally intended, and to meet this the shop was run at times at night as well as day on an 8-hour shift.

The shop as it was finally in full operation was a model of its kind and was praised by the manager of the English spectacle depot and by the consultants of the British ophthalmological service.

The eight auxiliary units were assigned to duty at the following stations:

Attending Surgeon's Office, G. H. Q	Chaumont.	Base Hospital No. 6	Bordeaux.
Base Hospital No. 18	Bazoilles.	Base Hospital No. 17	Dijon.
Base Hospital No. 1	Vichy.	Base Hospital No. 23	Vittel.
Base Hospital No. 27	Tours.	Base Hospital No. 8	Savenay.

Instructions regarding the functions of these units and the methods of requisitioning spectacles and lens were issued in a circular from the office of the Chief Surgeon as follows: [4]

MEMORANDUM.

HEADQUARTERS, AMERICAN EXPEDITIONARY FORCES,
Office of the Chief Surgeon, May 10, 1918.

Circular No.

1. An auxiliary optical unit has been sent to each of the following stations, viz:

Attending Surgeon's Office, G. H. Q	Chaumont.
Base Hospital No. 18	Bazoilles.
Base Hospital No. 1	Vichy.
Camp Hospital No. 27	Tours.
Base Hospital No. 6	Bordeaux.
Base Hospital No. 17	Dijon.
Base Hospital No. 23	Vittel.
Base Hospital No. 8	Savenay.

A central optical unit has been sent to the instrument repair shop of the medical supply depot in Paris.

2. Prescriptions for spectacles to be supplied free of charge to officers, nurses, and enlisted men of the A. E. F., may be sent to the commanding officer of these stations.

These standard spectacles are of nickel steel, round glass, and any combination of lens can be supplied or repairs made on short notice.

Unusual prescriptions and ordinary prescriptions for troops near Paris may be sent to the central unit. This unit will also repair any optical instruments used in hospitals.

Prescriptions should include not only the lens prescription but accurate measurements for frame, stating the following dimensions, viz: Pupillary distance, temporal width, height of crest above pupillary line, width of bridge at the base, inset or outset in millimeters, and length of temple.

As the size of the eye will be the same in all cases, namely, 40 mm., it will not be necessary to state that dimension.

These units did excellent work. Fortunately, while they were being organized in the United States arrangements had been made by which the personnel of the units carried their optometric supplies with them to France as personal baggage. Therefore, upon arrival, each unit was equipped with a goodly supply of cut and edged lenses, and frames with all necessary adusting tools, so that all ordinary prescriptions could be filled at once. Later they were handicapped by a lack of replacement lenses due to the delayed arrival of the supplies for the base unit which has previously been referred to. To offset this shortage of lenses, ophthalmic surgeons were requested not to prescribe weak spheres and cylinders unless very strongly indicated.

With the increase in the number of troops and hospitals in the American Expeditionary Forces, additional units were urgently needed. Accordingly request was made for six more auxiliary units and these arrived shortly after the armistice had been signed. Through some inadvertance these units did not bring with them their allotment of supplies although this had been arranged for and counted on. As has been already noted, the failure of supplies to accompany these units caused considerable confusion in the plans for supplying glasses.

Prior to the arrival of these last six units from the United States six units had been organized in the American Expeditionary Forces by selecting men with optical experience from the various base hospitals or from other optical units. These units were assigned to duty as needed.

The use of base and auxiliary optical units was a new feature in Medical Department organization and was more or less of an experimental nature. Their value was thoroughly proven and the work done of great importance.

There was necessarily a considerable delay in supplying glasses to organizations serving near the front, especially during the period of open fighting. To overcome this, plans were adopted for the organization of mobile optical units to travel from place to place, each provided with the necessary equipment for filling optical prescriptions. The cessation of hostilities prevented the carrying of these plans into execution.[3]

ARTIFICIAL EYES.

Fortunately, at the last minute, before leaving New York, 1,000 artificial eyes were added to the equipment of the base optical unit. During the summer 200 artificial eyes were selected by the senior consultant in ophthalmology from the supply in the hands of a manufacturer in Nantes, and still later 500 artificial eyes were sent over as part of the equipment of Base Hospital No. 115.[3]

At first small supplies of artificial eyes were sent to various base hospitals; but this plan was evidently a mistake, as it was often impossible to find in the small collection sent an artificial eye suitable for the individual case. It was, therefore, decided to establish centers for the fitting of artificial eyes. Accordingly a large supply was left at Base Hospital No. 115, at Vichy, and also at the base optical unit in Paris, and a supply sent to the port of embarkation for D cases at Savenay. After the decision to embark D cases from Bordeaux and Brest, a supply of artificial eyes was sent to Base Hospital No. 6 at Bordeaux and to Base Hospital No. 54 at Brest. A small supply was sent to Base Hospital No. 29, at Tottenham, England, as a number of men requiring artificial eyes were found in the various hospitals in base section 3 at the time of the visit of the senior consultant.[3]

It was thus hoped that no soldier who could be fitted with an artificial eye would be sent home without one.

Arrangements were made for those soldiers requiring minor plastic operations before the fitting of artificial eyes to have this work done at Vichy, Paris, Savenay, and to a smaller extent in all the base hospitals. Men requiring more extensive plastics to enable them to wear an artificial eye were routed to Vichy, or classified D and sent to the United States.

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(3) Report of Col. Allen Greenwood, Senior Consultant in Ophthalmology, A. E. F. On file, Historical Division, S. G. O.
(4) Memorandum Circular, Hdqrs., A. E. F., Office of Chief Surgeon, May 10, 1918. On file, Historical Division, S. G. O.

SECTION V.

OTOLARYNGOLOGY IN THE UNITED STATES.

INTRODUCTION.

The story of the organization of the Section of Otolaryngology as a branch of the Division of Head Surgery in the Office of the Surgeon General is told in Chapter XVIII of Volume I of this history. Included in that chapter are an account of the methods used in securing the officer personnel for this specialty, and a general résumé of the administrative problems involved. In the present volume, which covers the professional activities of certain of the specialties comprising the Division of Head Surgery, the otolaryngological work done in the camps and hospitals of this country, including the examination of the auditory and nasopharyngeal passages of recruits, are considered.

At each base and general hospital an otolaryngological service was established under the direction of an especially selected chief of large experience in civil life. As assistants in this service were detailed younger officers who also had practiced this specialty before entering the Army.

In all of the general and base hospitals special wards were assigned for the patients in the ear, nose, and throat service, and examining clinic rooms were provided, while in many instances separate operating rooms were equipped in which only otolaryngological operations were performed. Figures 1 to 10 show departments of the otolaryngological service in certain hospitals; they are typical of those generally existing in the Army.

Figures 11 to 18 illustrate the forms adopted at certain of the base and general hospitals for briefly recording the histories and results of examinations of otolaryngological patients. Similar cards were in use in the otolaryngological clinics of all the large hospitals.

Owing to the rapid mobilization of troops it was impossible for the supply department, at the outset, to provide complete outfits of surgical equipment pertaining to this specialty, and to issue to each hospital the particular instruments to which the various operators had become accustomed. This deficiency was overcome, in many instances, by otolaryngological officers taking with them to their stations instruments and appliances from their own collections. Later, a standardized list of instruments was adopted and these were supplied in sufficient quantities.

The history of all wars has shown that one of the great sources of noneffectiveness among troops is the appearance (especially during the period of mobilization) of epidemics of the infectious diseases. Experience during the

Fig. 1.—Otolaryngological clinic room, Base Hospital, Camp Upton, N. J.

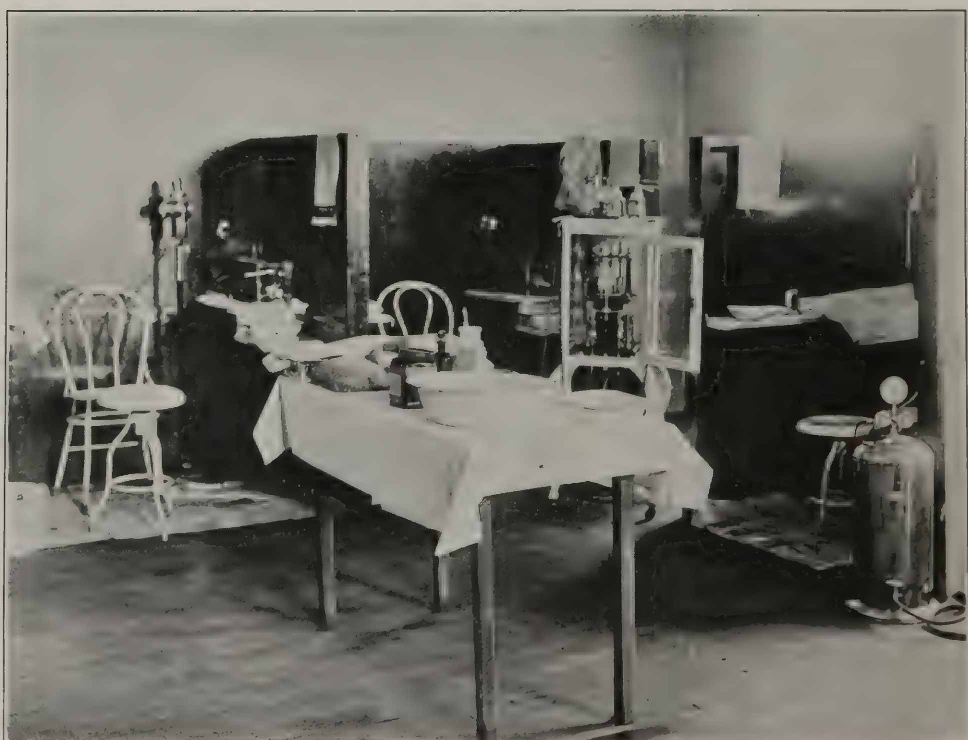


Fig. 2.—Treatment booths, otolaryngological service, Base Hospital, Camp Sheridan, Ala.

FIG. 3.—Otolaryngological clinic room, Base Hospital, Camp Lewis, Wash.

FIG. 4.—Otolaryngological operating room, Base Hospital, Camp Lewis, Wash.

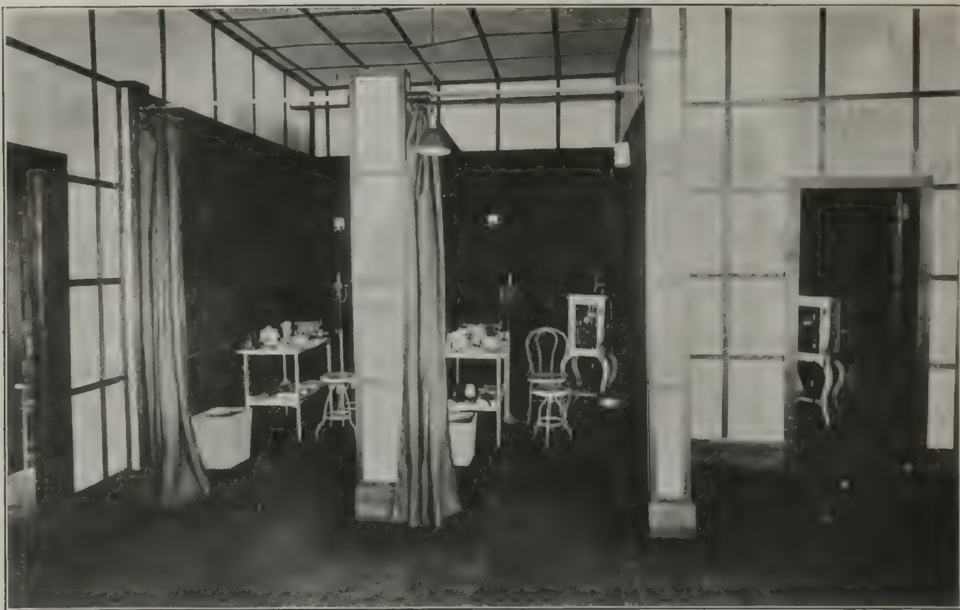


FIG. 5.—Ear, nose, and throat clinic, Base Hospital, Camp Jackson, S. C.

FIG. 6.—Operating room for otolaryngological service, Base Hospital, Camp Jackson, S. C.

FIG. 7.—Otolaryngological building, General Hospital No. 14, Fort Oglethorpe, Ga. (also used by department of otolaryngology, M. O. T. C., Camp Greenleaf).

FIG. 8.—Operating room for otolaryngological service, General Hospital No. 14, Fort Oglethorpe, Ga.

FIG. 9.—Treatment room, department of otolaryngology, General Hospital No. 14, Fort Oglethorpe, Ga

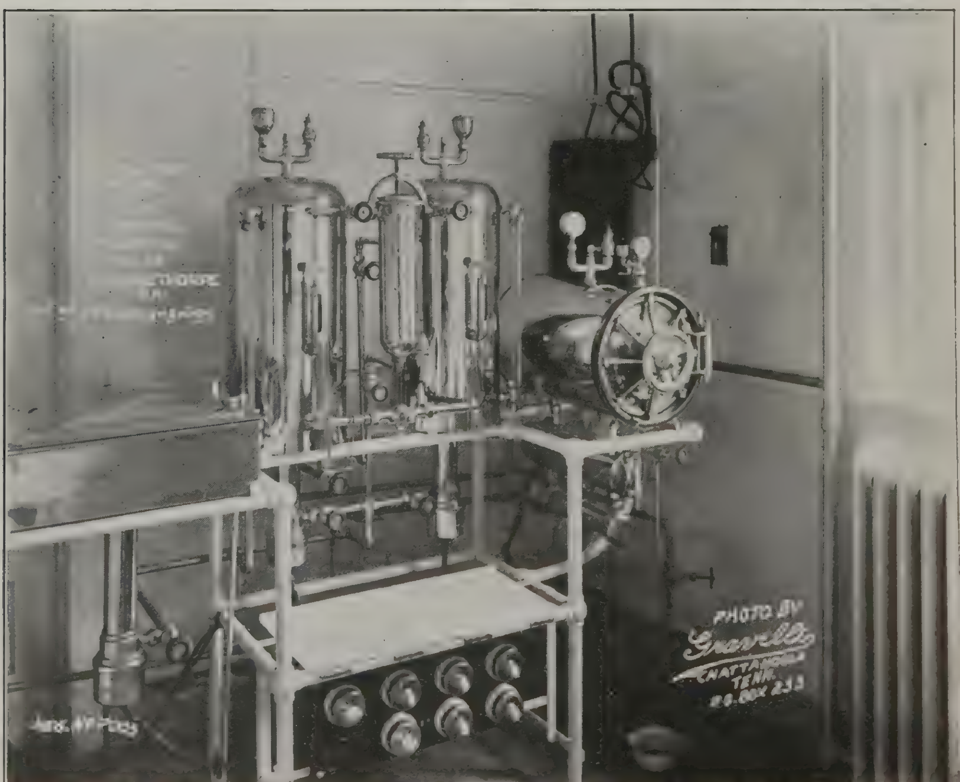


FIG. 10.—Sterilizing room, department of otolaryngology, General Hospital No. 14, Fort Oglethorpe, Ga.

TESTS	R	L	R	L	R	L	R	L
VOICE								
Conversation								
Whisper								
WATCH								
Small								
Ingersoll								
TUNING FORKS								
Weber								
Rinne								
Bing.								
Siegel								
Schwabach								
Contra C								
Gross C								
C 1								
C 2								
C 3								
C 4								
C 5								
GALTON WHISTLE								
NOISE APPARATUS								
NYSTAGMUS								
Spontaneous								
Head Movemt.								
Caloric								
Turning								
Galvanic								
Fist. Symptom								
Romberg								

LABORATORY EXAMINATION:

FIG. 11.—(Front.) Otolaryngological clinical record card used at Base Hospital, Camp Dodge, Iowa.

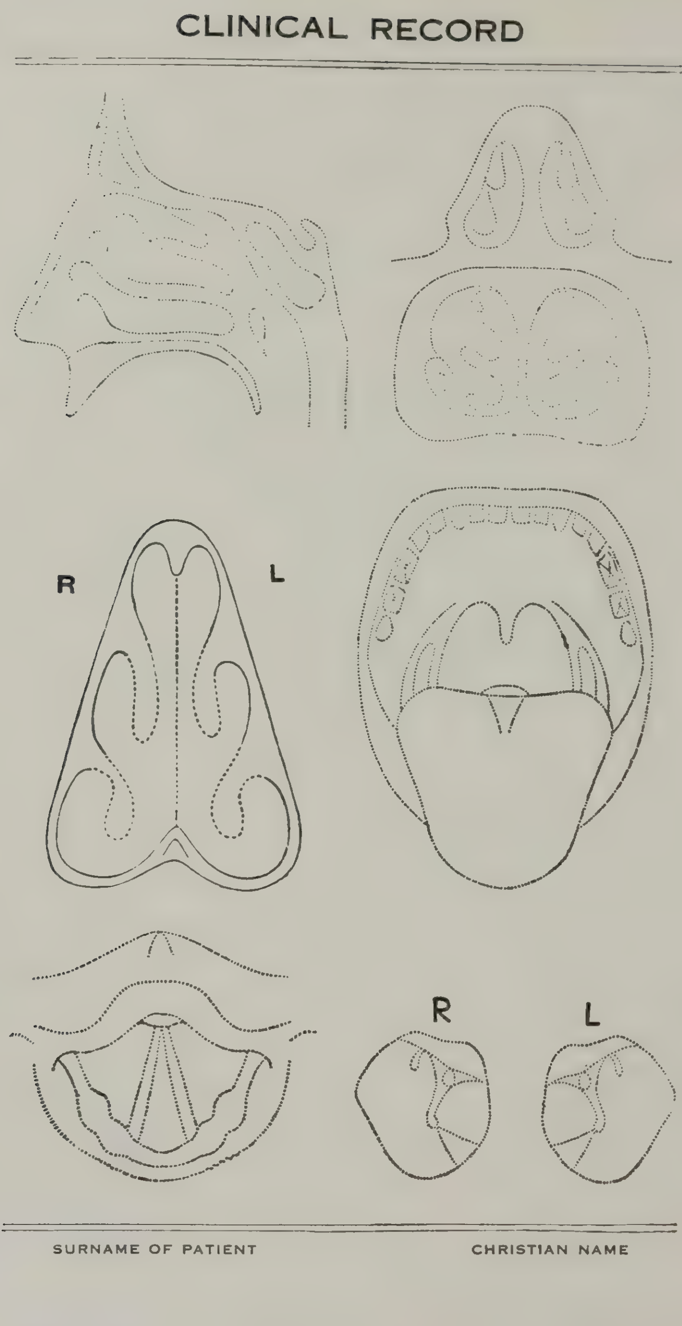


FIG. 12.—(Back.) Otolaryngological clinical record card used at Base Hospital, Camp Dodge, Iowa.

EAR, NOSE AND THROAT
EXAMINATION

(Rank) (Co.) (Organization)

(Age) (Race) (Nativity)

Date of Admission .... Date of Examination ....

Occupation .... Service, yrs. ....

Taste .... Smell ....

Nose and Naso-pharynx ....

Tongue .... Teeth & Gums .... Cheeks ....

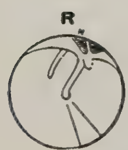
Pharynx ....

Lymphatics ....

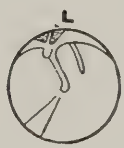
Larynx ....

Ears :

R



L



C. Fork B. A. B. A.

Acumeter ....

Recommendation ....

....

Examiner .... M. C., U. S. Army

Name of Patient

SURNAME CHRISTIAN NAME

(OVER)

FIG. 13.—(Front.) Otolaryngological clinical record card used at General Hospital No. 21, Denver, Colo.

World War demonstrated conclusively that, at that time, the majority of the infectious diseases gained access to the human body through the respiratory tract and that congenital defects and chronic inflammations of the upper portion of this tract might, in consequence, play a prominent rôle in the spread of disease.

Careful attention to this portion of the body, therefore, may be of the utmost importance in the prevention of disease. The work of the otolaryngologist in correcting septal deviations, removing diseased tonsils, and treating the chronic inflammations of the nose and throat as well as of the accessory sinuses must have been of the greatest assistance in reducing the sick rate of the Army. The importance of a healthy nose and throat in the prevention of diseases can not be too strongly emphasized. As the standards of physical requirements for entrance into the Army provided that many nasal and pharyngeal defects were not causes for rejection, it was evident that a large number of men after joining the Army would require otolaryngological treatment to place them in a satisfactory physical condition.

To a very large extent the class of patients which came under the treatment of the otolaryngological specialists was similar to that encountered in civil life. Little of what might be designated as military surgery was encountered in this country. Destructive gunshot lesions, which involved the auditory or nasopharyngeal passages, by the time they arrived in the homeland had reached a stage in reparative processes where only further plastic operations were required. Such operations were performed by officers of the maxillofacial service. In the section of this volume pertaining to that specialty many conditions covering destruction of the ears or nose are considered.

In preparing this section recourse has been made to the reports received from the senior otolaryngologists on duty at the various base and general hospitals, as well as to special reports and reviews submitted from time to time by medical officers attached to the otolaryngological service. All these reports are now on file in the Office of the Surgeon General.[1]

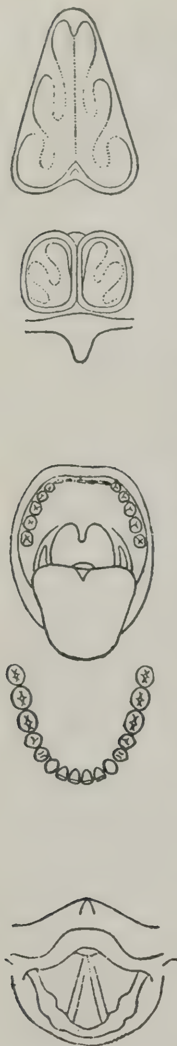


FIG. 14.—(Back.) Otolaryngological clinical record card used at General Hospital No. 21, Denver, Colo.

REFERENCES.

(1) Reports, on file, Record Room, S. G. O., 730 (Otolaryngology) (name of hospital).

Form 55 d
MEDICAL DEPARTMENT, U. S. ARMY
(Authorized Jan. 17, 1916.)

CLINICAL RECORD

SUBJECTIVE SYMPTOMS

Condition on admission: DATE.....................191.....

RIGHT NOSE LEFT

External
Muc. Memb.
Secretion
Septum
Mid. Turb.
Inf Turb.
ACC. SINUS
Frontal
Maxillary
Ethmoid
Sphenoid
TRANSILLUM

THROAT

Tongue
Teeth
Pharynx
Tonsils
Nasopharynx
Larynx

Trachea

RIGHT EAR LEFT

Canal
Pain
Discharge
Tinnitus
Middle Ear

Mastoid

(OVER)

SURNAME OF PATIENT CHRISTIAN NAME

Ed. Mar. 6–18—5,000,000. c 3—3673

FIG. 15.—(Front.) Otolaryngological clinical record card used at General Hospital No. 11, Cape May, N. J.

AUDITORY TESTS

	RIGHT	LEFT
Whisper, Low, Loud.............	....	....
Voice, Low, Loud, Shout.........	....	....
Watch or Acumeter................	....	....
Tone Limit Upper Galton.... ...	....	....
Lower, Fork (D. V.)	....	....
Weber..............................	....	....
Rinne..............................	....	....
(Duration) Air.....................	....	....
Bone..................	....	....

VESTIBULAR REACTIONS (SPONTANEOUS)

RIGHT LEFT

Nystagmus
Pointing
Falling

ROTATION TESTS

Turn to Rt , Nyst. to Lt. sec.
Turn to Lt., Nyst. to Rt. sec.

PAST POINTING

Turn to Rt., Rt. Hand L Hand
Turn to Lt., Rt. Hand L Hand

FALLING

Turn to Rt., Falls to
Turn to Lt., Falls to

CALORIC

Right Ear
Left Ear

SUMMARY

FIG. 16.—(Back.) Otolaryngological clinical record card used at General Hospital No. 11, Cape May, N. J.

Rank

Diagnosis

History

Exam. nose

acc. sin.

pharynx

naso. ph.

larynx

ears

Hearing-Watch R.E. /40; L.E. /40

Low Conv. voice R.E. /20; L.E. /20. After Pol R.E. /20 L.E. /20

Rinne R.E. L.E.

Treatment:

FIG. 17.—Otolargyngological clinical record card used at Base Hospital, Camp Lewis, Wash.

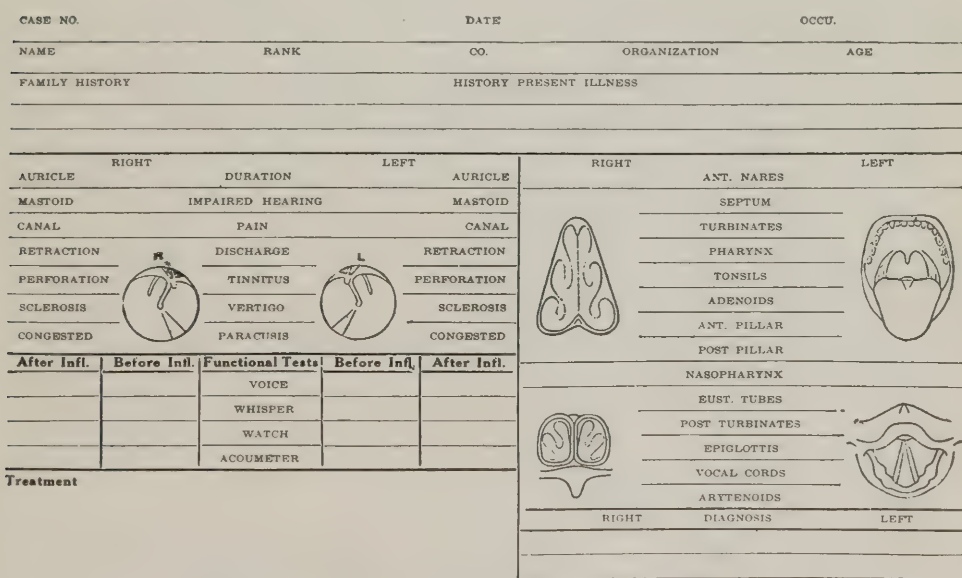


FIG. 18.—Otolaryngological clinical record card in use in various hospitals.

CHAPTER I.

EXAMINATION OF RECRUITS.

The examination of the nose, throat, and ears has always been regarded as a very important part of the physical examination of recruits and draftees prior to their acceptance into the military service, many defects of these organs necessarily rendering the applicant unable to perform the duties of a soldier.

Among the conditions which were regarded during the period of the World War as absolute disqualifications for military service were chronic purulent otitis media, with or without mastoiditis; irremediable deformities of the mouth, throat, and nose, which interfered with the mastication of ordinary food, with speech or with breathing; tuberculosis, cancer, and destructive syphilitic disease of the mouth, nose, or throat; laryngeal paralysis due to pressure from aneurysm or tumor; and chronic sinusitis of the accessory sinuses of the nose. Certain other defects which, while considered as disqualifying for general military service, were not regarded as preventing men from being accepted for special or limited service, included perforation of the membrana tympani without discharge; deviation of the nasal septum, even though it markedly interfered with nasal breathing; paralysis of the vocal cords; and aphonia, if the man had been able to follow a useful vocation in civil life.

From the service viewpoint the aural examination was probably of the greater importance. Unless this examination was most carefully conducted, men with chronic otitis media were accepted and, in a very large proportion of cases, proved entirely unsuitable as soldiers. The unavoidable exposure to which soldiers were subjected almost invariably caused an increase in suppuration, if not an actual extension in bone destruction. A large number of these patients developed a mastoid involvement, for which operation was required. Soldiers with a chronic otitis media necessarily spent a large portion of their time in hospital or in applying for treatment at out-patient clinics, thus greatly interfering with their military training, and finally ending their service with a discharge on account of physical disability.

Another phase of the aural examinatoin which required care and study was the detection of malingerers. While it is not believed that deception was practiced to any great extent to avoid service during the war, a certain number of such cases occurred, and the ears offered a fertile field for frauds of this character. Defective hearing is easily feigned and its detection often resolves itself into a battle of wits between the examiner and the man being examined. Malingering was a new subject to the medical officers who had recently come from civil life, and for their guidance definite instructions were issued regarding the best methods of detecting such deceptions.[1]

While the malingering which came to the attention of the aurist concerned itself most frequently with defective hearing, this was not always the case, as is shown by the following incident: A young man of foreign birth appeared before an examining board. The ear was wiped out, but something about the odor attracted the attention of the examiner. It was offensive, but it was not just

the odor with which he had become familiar in his clinic. When the ear was wiped dry a pink granulation was seen to block the canal. Something impelled the examiner not to reject the man without further scrutiny and he directed that the canal be washed out. The syringe brought out the granulation, whereupon examination revealed a normal canal and a normal drum. The man then confessed. A relative of his, a physician, had promised to get him rejected. Accordingly, he had placed a piece of meat in the applicant's ear and had filled the canal with an abundant discharge made of powdered cheese mixed with water.[2]

The diseased conditions of the nasopharynx which were causes of rejection were of comparatively rare occurrence, but the fact that enlarged tonsils (without restriction), adenoids, and deflected septums did not cause the rejection of recruits paved the way for a large volume of operative work to be done in the future before the young men who were thus handicapped could render really efficient service. As aphonia without objective findings by laryngoscopy was not a cause for rejection, there was no opportunity for malingering in this regard.

The examination of the first increment of the draft which arrived at the camps was conducted by the regimental surgeons, and only subjects concerning whom they were in doubt were referred to the otolaryngologists for the special examination. This scheme was shortly changed and the examination of the ears, nose, and throat of all recruits was conducted by specially designated officers assigned from the otolaryngological service. In many of the camps reexaminations of those previously accepted were conducted and men who had disqualifying defects were discharged. The following extract from a report of the otolaryngological service at Camp Meade is of interest in this connection:[3]

A review of the history of otolaryngology at Camp Meade would be incomplete without some word as to the examining of recruits in the camp. In November, 1917, a verbal request was made by the division commander of the Seventy-ninth Division for the head of the otolaryngology staff at the base hospital to take charge of the ear, nose, and throat examination of recruits. This work was all done down in the camp, away from the base hospital. There was, unfortunately, a good deal of shifting around of the special examining boards, but finally rather elaborate quarters were installed in the barrack B–38 for use of eye, ear, nose, and throat boards. There was distinct advantage in having this examining work placed in charge of the ear, nose, and throat department of the base hospital, because when the examining work was heavy men could be detailed from the base hospital to help out in camp, and vice versa when the examining work was light in camp and the base hospital work was heavy these men could be returned to base hospital. The duty of the special board was to examine and recommend disposition of all patients referred to it. The majority of these were new recruits who were picked out at the general physical examinations, but this board also acted on a large number who had been in the service for some time.

REFERENCES.

(1) General Instructions for Medical Officers of the Section of Head Surgery, Surgeon General's Office, November 27, 1917. On file, Record Room, S. G. O., 730.

(2) Mosher, H. P.: A Summary of the Activities of the Section of Otolaryngology. *The Military Surgeon*, Washington, D. C., 1918, xliii, No. 12, 631.

(3) Report on otolaryngology, by Maj. George B. Wood, M. C., December 13, 1918. On file, Record Room, S. G. O., 730. (Otolaryngology) Camp Meade (D).

CHAPTER II.

STATISTICS.

During the period of the war monthly reports were submitted by the chief of the ear, nose, and throat service at each base and general hospital. These reports covered the patients seen in the ear, nose, and throat clinics and included many who were not actually on sick report and hence are not included in the general statistical tables prepared by the Statistical Division of the Surgeon General's Office. The monthly reports in question were studied and from them figures were compiled in the Office of the Surgeon General. The consolidated returns for the period from March 1, 1918, to February 29, 1919, inclusive, are included in Tables 1 and 2. The data furnished for other months were not sufficient to warrant their incorporation in these tables. It must not be understood that all military stations in this country are included in these reports. Such is not the case, but for most of the months in question reports from 32 base hospitals at the large camps, 14 general hospitals, and the base hospitals at the camps of embarkation, are included, as well as those from a few of the larger posts. The actual strength of the portion of the Army from which these cases were drawn can not be determined, but, as the majority of the large camps are included, the total strength represented must have been a large percentage of the troops on duty in this country for the period mentioned.

TABLE 1.—*Diseases treated in ear, nose, and throat clinics, base and general hospitals, March 1, 1918, to February 28, 1919, inclusive.*[1]

	March.	April.	May.	June.	July	August.	September.	October.	November.	December.	January.	February.	Total.
Otitis, externa, circumscr	5	6	......	......	......	......	3	10	8	3	......	3	38
Furunculosis of ear	3	6	7	7	7	8	16	26	27	9	4	8	128
Otitis media, acute, nonsup	25	41	15	7	9	8	21	54	20	18	8	13	239
Otitis media, acute sup	162	259	151	89	53	60	180	556	335	286	277	143	2,551
Otitis media, chronic sup	9	6	7	5	6	9	14	13	13	4	11	4	101
Mastoiditis, acute	319	271	168	105	50	45	46	74	262	225	204	138	1,907
Mastoiditis, chronic	15	13	12	7	7	7	8	6	10	1	11	11	108
Lateral sinus thrombosis	4	3	2	......	1	3	1	1	11	3	5	8	42
Rhinitis, chronic	18	12	20	10	7	5	4	......	7	2	3	2	90
Deviation nasal septum	321	370	401	449	378	497	395	54	294	163	171	138	3,631
Turbinates, hypertrophied	36	31	63	58	78	80	57	28	60	37	10	23	561
Fracture nasal bones	7	8	10	4	6	15	5	4	9	10	4	6	88
Ethmoiditis, acute	3	4	7	4	2	12	......	......	4	3	7	1	47
Ethmoiditis, chronic	32	32	48	40	27	41	43	12	21	12	16	11	335
Sphenoiditis, acute	1	2	......	1	1	......	......	......	......	......	2	......	7
Sphenoiditis, chronic	......	......	1	......	......	3	1	......	......	......	......	......	5
Frontal sinusitis, acute	30	25	18	14	4	20	5	15	22	6	12	10	181
Frontal sinusitis, chronic	9	9	4	8	3	5	12	1	4	4	9	10	78
Empyema maxillary sinus	47	86	67	52	40	65	74	46	35	49	23	33	617
Adenoids, hypertrophied	16	302	359	244	263	292	212	14	178	87	104	97	2,168
Tonsils, hypertrophied	930	962	1,143	1,190	1,276	1,319	1,298	265	758	382	316	351	10,190
Acute, fol. tonsillitis, bilateral	25	23	37	15	4	9	20	3	18	4	12	13	183
Chronic, fol. tonsillitis, bilateral	499	585	316	587	583	1,403	1,258	185	792	443	461	497	7,609
Peritonsillar abscess	211	238	138	81	106	118	81	73	111	200	220	145	1,722
Adenitis, cervical	1	3	1	1	1	1	......	......	1	2	......	4	15
Papilloma vocal cord	2	1	......	1	......	2	3	......	6	......	1	1	17
Meningcoccus carriers, tonsils	1	......	......	2	......	......	......	......	......	1	......	......	4
Diphtheria carriers, tonsils	129	......	19	15	......	1	2	......	......	5	1	9	181

TABLE 2.—*Operations performed in ear, nose, and throat clinics, base and general hospitals, March 1, 1918, to February 28, 1919, inclusive.*[1]

	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	Total.
Myringotomy	217	294	214	101	61	69	210	620	354	268	265	123	2,796
Mastoidectomy, simple	379	266	176	113	57	45	41	82	262	233	211	134	1,999
Mastoidectomy, radical	9	27	13	4	5	1	4	4	9	6	4	4	90
Secondary mastoid operation	1	......	......	9	15	31	13	2	12	14	13	13	123
Turbinectomy	101	91	116	151	92	112	105	50	108	60	46	45	1,077
Nasal spurs removed	10	24	19	18	22	24	21	2	6	4	8	3	161
Nasal polyps removed	21	29	57	46	21	46	44	14	38	15	25	17	373
Submucous resection nasal septum	337	364	401	446	386	493	395	46	293	173	139	137	3,610
Exenteration ethmoids	41	31	42	38	28	52	40	10	20	11	17	8	338
Radical op., antrum of Highmore	10	5	7	4	7	14	7	3	7	8	9	26	107
Partial uvulotomy	8	17	6	9	11	10	9	1	2	2	3	2	80
Adenoidectomy	42	53	62	53	30	46	21	1	27	13	13	7	368
Tonsillectomy	1,428	1,245	1,341	1,469	1,304	2,216	1,694	346	1,003	522	533	635	13,736
Tonsillectomy and adenoidectomy	290	302	356	358	324	293	371	13	148	69	94	90	2,708
Post-op. tons. hemorrhage	4	......	4	1	3	8	......	1	4	......	......	2	27
Mosher operation	5	1	......	......	......	......	......	......	......	......	1	......	7
Killian operation	......	2	3	2	......	4	1	......	4	2	2	2	22
Other operations	38	78	93	85	40	61	54	39	78	73	60	73	772

While, for the reasons stated, Table 1 does not give a correct conception of the rate of occurrence of the defects and diseases noted compared with the strength of the Army, it does give a true picture of the seasonal occurrence of the diseases considered.

The records pertaining to otolaryngological operations performed are lacking in that one or more monthly reports were not received from practically every hospital. For this reason the report of operations compiled in the Division of Head Surgery in the Office of the Surgeon General, Table 2, is not complete. Detailed reports of operations from several individual hospitals are given below. These reports do not cover the same period of time in each case, but give a very good idea of the extent of the operative work done in the ear, nose, and throat services of the base hospitals throughout the country.

TABLE 3.—*Operations performed in the ear, nose, and throat clinic, Base Hospital, Camp Bowie, Tex., during the year 1918.*[1]

	Tonsillectomy.	Adenoidectomy.	Peritonsillar abscess.	Submucous resection.	Mastoidectomy.	All other operations.	Total.
January	62	....	....	10	18	60	150
February	45	3	....	20	29	15	112
March	47	....	....	16	31	11	105
April	52	....	....	7	14	4	77
May	41	....	....	28	4	8	81
June	36	....	....	21	3	10	70
July	14	....	....	14	1	....	29
August	7	4	....	12	2	1	26
September	13	....	3	16	1	19	52
October	1	....	....	2	7	19	29
November	9	1	....	9	7	5	31
December	6	....	3	....	4	18	31
Total	333	8	6	155	121	170	794

TABLE 4.—*Operations performed in the ear, nose, and throat clinic, Base Hospital, Camp Cody, N. Mex., during the year 1918.*[1]

	Tonsil-lectomy.	Adenoid-ectomy.	Periton-sillar abscess.	Submu-cous resec-tion.	Mastoid-ectomy.	All other opera-tions.	Total.
January	6	1	....	....	26	1	34
February	84	1	....	....	3	12	100
March	40	3	....	....	35	....	78
April	41	3	....	....	3	6	50
May	53	....	....	2	3	....	58
June	88	1	3	3	....	2	97
July	71	....	1	6	2	2	82
August	43	1	....	3	4	7	58
September	36	1	....	....	....	1	38
October	5	....	....	2	....	12	19
November	12	....	....	9	4	1	26
December	....	....	....	....	1	1	2
Total	479	8	4	25	81	45	642

TABLE 5.—*Operations performed in the ear, nose, and throat clinic, Base Hospital, Camp Lee, Va., during the year 1918.*[1]

	Tonsil-lectomy.	Adenoid-ectomy.	Periton-sillar abscess.	Submu-cous resec-tion.	Mastoid-ectomy.	All other opera-tions.	Total.
January	5	2	....	1	4	42	54
February	12	....	....	....	21	48	81
March	45	....	....	4	29	4	82
April	29	....	6	7	15	22	79
May	26	....	4	5	2	20	57
June	47	....	3	3	5	15	73
July	99	....	....	22	2	21	144
August	398	1	6	14	2	61	482
September	210	....	3	10	1	6	227
October	6	....	....	1	3	5	18
November	60	....	2	17	8	21	108
December	21	....	2	7	7	13	50
Total	958	3	26	91	99	278	1,455

TABLE 6.—*Operations performed in the ear, nose, and throat clinic, Base Hospital, Camp Pike, Ark., during the year 1918.*[1]

	Tonsil-lectomy.	Adenoid-ectomy.	Periton-sillar abscess.	Submu-cous resec-tion.	Mastoid-ectomy.	All other opera-tions.	Total.
January	1	3	....	....	40	....	44
February	74	3	....	7	53	8	145
March	78	8	3	14	32	11	146
April	105	4	13	5	13	57	197
May	68	5	7	5	14	36	135
June	74	2	....	....	2	29	107
July	47	2	....	9	5	45	108
August	80	2	3	9	3	41	138
September	64	....	5	9	3	52	133
October	3	....	6	1	11	73	94
November	....	....	10	....	39	15	64
December	1	....	2	....	21	17	41
Total	595	29	49	59	236	384	1,352

TABLE 7.—*Operations performed in the ear, nose, and throat clinic, Base Hospital, Camp Shelby, Miss., during the year 1918.*[1]

	Tonsillectomy.	Adenoidectomy.	Peritonsillar abscess.	Submucous resection.	Mastoidectomy.	All other operations.	Total.
January	81	10	....	4	64	14	173
February	....	....	....	....	....	....	....
March	58	2	....	19	15	33	127
April	48	6	....	13	5	23	95
May	87	3	....	6	....	17	113
June	49	4	2	....	2	11	68
July	94	6	1	15	1	13	130
August	73	5	5	26	....	28	137
September	29	2	5	5	9	36	86
October	1	....	3	1	....	19	24
November	12	....	....	2	3	12	29
December	12	1	1	11	4	12	41
Total	544	39	17	102	103	218	1,023

TABLE 8.—*Operations performed in ear, nose, and throat clinic, Base Hospital, Camp Taylor, Ky., during the year 1918.*[1]

	Tonsillectomy.	Adenoidectomy.	Peritonsillar abscess.	Submucous resection.	Mastoidectomy.	All other operations.	Total.
January	....	....	....	....	2	1	3
February	72	65	....	5	26	9	177
March	26	2	....	8	33	53	122
April	15	9	....	8	14	75	121
May	64	6	....	5	19	11	105
June	11	2	....	3	1	55	72
July	11	2	....	2	2	124	141
August	83	....	....	11	....	5	99
September	46	3	24	5	1	57	135
October	....	....	....	....	1	....	....
November	8	....	....	1	58	5	72
December	5	....	58	....	54	17	134
Total	341	89	82	48	211	413	1,182

TABLE 9.—*Operations performed in ear, nose, and throat clinic, Base Hospital, Camp Dodge, Iowa, December 1, 1917, to January 31, 1919, inclusive.*[1]

	Tonsillectomy.	Paracentesis.	Adenoidectomy.	Abscess of tonsil.	Antrum.	Mastoidectomy.	Septum submucous resection.
1917.							
December	67	5	....	7	2	6	21
1918.							
January	79	18	....	33	8	9	14
February	84	13	1	27	8	10	20
March	92	30	....	30	13	4	11
April	63	18	....	26	30	8	9
May	118	6	3	4	19	5	5
June	104	4	....	12	10	7	17
July	129	1	1	13	2	6	17
August	122	2	....	7	2	6	12
September	94	2	4	6	3	....	4
October	....	7	....	12	....	2	....
November	16	3	1	12	4	6	9
December	1	2	....	30	1	7	3
1919.							
January	27	2	....	29	....	4	11
Total	996	113	10	248	102	80	153

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TABLE 10.—*Operations performed in ear, nose, and throat clinic, Base Hospital, Camp Gordon, Ga., during the year 1918.*[1]

	Myringotomy.	Mastoidectomy.	Adenoidectomy.	Tonsillectomy.	Submucous resection.	Incision and drainage of peritonsillar abscess.	Other operations.
January	....	2	1	25	10	....	4
February	....	10	3	24	9	....	....
March	....	5	3	32	29	....	4
April	....	3	2	31	16	....	....
May	....	2	2	36	15	....	3
June	....	6	6	53	20	....	5
July	....	2	5	101	31	....	....
August	11	4	4	98	25	6	1
September	24	7	5	75	10	3	2
October	56	1	....	1	....	9	....
November	8	5	....	23	5	6	2
December	17	1	....	3	1	11	1
Total	116	48	31	502	171	35	22

TABLE 11.—*Operations performed in ear, nose, and throat clinic, Base Hospital, Camp Lewis, Wash., during the year 1918.*[1]

	Tonsillectomy.	Adenoidectomy.	Peritonsillar abscess.	Submucous resection.	Mastoidectomy.	All other operations.	Total.
January	91	43	16	24	14	74	262
February	11	3	10	37	17	20	98
March	3	10	20	10	23	44	110
April	12	5	13	10	21	42	103
May	93	16	17	30	13	43	212
June	59	13	9	29	6	22	138
July	42	12	5	8	3	9	79
August	40	17	10	11	3	7	88
September	61	80	13	28	....	28	138
October	56	3	11	6	7	46	129
November	69	16	19	20	9	34	167
December	8	....	7	3	8	44	70
Total	545	146	150	216	124	413	1,594

TABLE 12.—*Operations performed in ear, nose, and throat clinics, other base hospitals, during the war period.*[2]

Base Hospital, Camp Custer, Mich., December 11, 1917, to February 1, 1919:	
Peritonsillar abscesses (incision)	286
Mastoidectomy	79
Myringotomy	245
Submucous resection	73
Tonsillectomy	277
Base Hospital, Camp Doniphan, Okla., October, 1917, to December 18, 1918:	
Mastoidectomy	80
Turbinectomy	8
Sinus operations	7
Submucous resection	33
Tonsillectomy	452
Adenectomy	16
Base Hospital, Camp Jackson, Miss., January 1, 1918, to December 1, 1918:	
Tonsillectomy	371
Submucous resection	58
Myringotomy	238
Mastoidectomy	44
Adenoidectomy	25
Turbinectomy	37
Peritonsillar abscesses (incision)	67
Base Hospital, Camp MacArthur, Tex., October 6, 1917, to February 10, 1919:	
Mastoidectomy, simple	42
Mastoidectomy, radical	6
Myringotomy	148
Submucous resection	318
Exenteration ethmoids	31
Tonsillectomy	1,282
Peritonsillar abscesses (incision)	325
Turbinectomy	55
Base Hospital, Camp Sheridan, Ala., February 25, 1918, to January 31, 1919:	
Myringotomy	82
Mastoidectomy	28
Base Hospital, Camp Sheridan, Ala., February 25, 1918, to January 31, 1919—Cont.	
Tonsillectomy	596
Adenoidectomy	33
Submucous resection	174
Base hospital, Camp Sherman, Ohio, year of 1918:	
Mastoidectomy, simple	98
Mastoidectomy, radical	19
Mastoidectomy, secondary	10
Myringotomy	338
Tonsillectomy	1,040
Peritonsillar abscesses (incision)	254
Base Hospital, Camp Wheeler, Ga., October 17, 1917, to March 6, 1919:	
Mastoidectomy	77
Submucous resection	64
Tonsillectomy	252
Turbinectomy	59
Peritonsillar abscesses (incision)	12
Myringotomy	105
General Hospital No. 14, Fort Oglethorpe, Ga. (acted as base hospital for Camps Greenleaf and Forrest), January 1, 1918, to July 14, 1918:	
Mastoidectomy	89
Tonsillectomy and adenectomy	191
Operations upon nose	25
Base Hospital, Fort Sam Houston, Tex., April 7, 1917, to January 1, 1919:	
Mastoidectomy, simple	18
Mastoidectomy, radical	1
Mastoidectomy, secondary	2
Submucous resection	506
Peritonsillar abscesses (incision)	46
Adenoidectomy	69
Tonsillectomy	541
Myringotomy	274

In all of the foregoing tabulations only the conditions fairly frequently encountered have been enumerated. It must not be supposed that a great variety of other work was not done. Practically all diseases and defects of the ear, nose, and throat were observed and treated in the clinic at each hospital, but for only a few are complete reports available. In a few instances the chief of the otolaryngological service at a base hospital included in his report a summary of all work done. To give the reader a more exact idea of the vast amount of otolaryngological work, the number of cases treated, as well as all operations performed, in a few camps are presented below. The character and amount of work shown by these reports is typical of that done in the ear, nose, and throat department of other base and general hospitals.

TABLE 13.—*Diseases treated and operations performed in ear, nose, and throat clinics, Base Hospital, Camp Sherman, Ohio, during the year 1918.*[3]

Number of new cases treated	7,311
Number of treatments given	35,261
Number of operations performed	2,226

CASES TREATED.

Abscess, peritonsillar	200
Abscess, retropharyngeal	1
Abscess, cervical	1
Adenoids	430
Deviation of nasal septum	675
Diphtheria in pus from discharging ears	11
Diphtheria carrier, nasopharynx	16
Epistaxis	15
Erysipelas	2
Exostosis, external auditory canal	2
Foreign body in external auditory canal	2
Herpes labialis	1
Hypertrophied tonsils	481
Impacted cerumen	335
Laryngitis	315
Lymphadenitis	24
Malingering	2
Mastoiditis, acute, suppurative	121
Mastoiditis, acute, suppurative (Bezold abscess)	2
Mastoiditis, chronic, suppurative	35
Meningitis carrier	1
Myringitis	6
Nasopharyngitis	87
Nerve deafness	14
No pathological condition	202
Nares, furuncle of	4
Otitis externa, circumscribed (furuncle)	65
Otitis externa, circumscribed (eczema)	12
Otalgia	1
Otitis media, acute catarrhal	265
acute suppurative	264
chronic catarrhal	329
chronic suppurative	295
Otosclerosis	5
Ozena	5
Palate, cleft	4
Palate, cleft, and harelip	1
Palsy, Bell's	1
Paralysis of vocal cords	1
Perichondritis (frostbite)	1
Pharyngitis	366
Rhinitis, acute catarrhal	229
Rhinitis, atrophic	77
Rhinitis, hypertrophic	118
Rose cold	8

CASES TREATED—continued.

Sebaceous cyst (ear)	1
Sebaceous cyst (nose)	2
Sinusitis, frontal, acute catarrhal	63
chronic catarrhal	9
acute suppurative	31
chronic suppurative	11
maxillary, acute catarrhal	14
chronic catarrhal	2
acute suppurative	14
chronic suppurative	25
ethmoidal, acute catarrhal	22
chronic catarrhal	19
acute suppurative	33
chronic suppurative	74
sphenoidal, acute catarrhal	10
chronic catarrhal	2
acute suppurative	3
chronic suppurative	1
Streptococcus hemolyticus carrier	9
Syphilis, secondary manifestations	13
Syphilis, tertiary manifestations	14
Subperiosteal abscess (ear)	1
Subperiosteal abscess (upper jaw)	2
Teeth, focal infection of, with ear complication	67
Thrombosis, lateral sinus	2
Tonsillitis, acute suppurative	276
Tonsillitis, chronic	1,314
Tonsils, focal infection of	6
Tonsils, lingual	4
Tubotympanic catarrh	92
Ulcer of nasal septum	62
Vincent's angina	28

Traumatisms.

Auricle, injury of	2
Contusion of nose	1
Contusion of nose, with laceration	1
Contusion of ear, with hematoma	1
Dislocation of nose	1
Fracture of nose, compound	1
Fracture of nose, simple	15
Traumatic atresia, external auditory canal	1
Total	7,311

TABLE 13.—*Diseases treated and operations performed in ear, nose, and throat clinics, Base Hospital, Camp Sherman, Ohio, during the year 1918*—Continued.

OPERATIONS.	
Simple mastoidectomy	98
Radical mastoidectomy	19
Secondary mastoidectomy	10
Blood clot closure of mastoid wound	25
Curettement of mastoid wound	5
Thiersch skin-grafting, postoperative mastoid wound	3
Removal of false membrane and pocket on meato-mastoid wound	5
Incision and drainage of Bezold abscess	1
Incision and drainage of abscess, lower end of mastoid wound	1
Incisions of membrana tympani	338
Aural polypi removed	5
Curettage of cyst, external auditory meatus	1
Removal of granular mass, external auditory canal	1
Removal of exostosis, external auditory canal	1
Removal of granulations, middle ear cavity	1
Incision and drainage of otitis externa	25
Incised sebaceous cyst, posterior surface of right lobule	1
Incised abscess, posterior surface of right lobule	1
Removal of hematoma, external ear	3
Submucous resection of nasal septum	70
Tonsillectomy (only)	24
Adenoidectomy (only)	4
Tonsillectomy and adenoidectomy	1,016
Cauterization of tonsil stub	1
Removal of lymph tissues, tonsillar fossa	1
Removal of lingual tonsils	1
Incision and drainage of peritonsillar abscess	254
Middle turbinectomy	38
Inferior turbinectomy	14
Removal of nasal spur	15
Furunculosis, vestibule of nose, incision	5
Removal of nasal polyp	22
Opening in naso-antral wall beneath inferior turbinate	30
Caldwell-Luc op., maxillary antrum	6
Opening antrum through canine fossa	4
Removal of sequestrum (compound fracture of nasal bones)	1
OPERATIONS—continued.	
Cauterization of turbinate	1
Removal of granuloma of septum	2
Replacement and suturing of fractured and lacerated parts of nose, due to kick of mule	1
Section of tumor in nose	1
Submucous resection of inferior turbinate	3
Excision of synechia between nasal septum and right inferior turbinate	1
Hematoma of septum, nasal, removed	2
Uvulotomy	4
Removal of papilloma, right anterior pillar of fauces	1
Scarification of edematous epiglottis	2
Tracheotomy	1
Cleft palate	1
Incised and drained cyst of salivary gland	1
Incised and drained pharyngeal abscess	1
Incised and drained abscess of soft palate	2
Killian operation, radical	2
Ligation of internal jugular and opening of lateral sinus	2
Exenteration of ethmoid cells	6
Exploratory opening of ethmoid cells	3
Exploratory opening of frontals	5
Puncture of antrum and irrigation	120
Radical opening sphenoid cells	2
Exploratory opening of frontal sinus, ethmoids and antrum	1
Removal of anterior wall of sphenoid	2
Closure of fistula into antrum	1
Incision and drainage of cervical lymph adenitis	1
Incision and drainage of brain abscess	3
Incision and drainage of subperiosteal occipital swelling	1
Incision and drainage of abscess of neck	1
Incision of skin of sternocleidomastoid muscle for counterdrainage	1
Incision and drainage of carbuncle on upper lip	1
Total number of operations for year	2,225

TABLE 14.—*Diseases treated and operations performed in ear, nose, and throat clinics, Base Hospital, Camp Merritt, N. J., February 19 to December 31, 1918, inclusive.*[4]

IN OUT-PATIENTS' CLINIC.

Ear cases:		
Myringitis, acute		30
Tubal catarrh		102
Otitis media, catarrhal, acute		95
Otitis media, catarrhal, chronic		178
Otitis media, purulent, acute		69
Otitis media, purulent, chronic		178
Otosclerosis		4
Polypi		1
Tinnitis (shell shock)		1
Otitis externa—		
circumscripta	52	
diffusa	24	
abscess lobe	2	
		78
Cerumen, impacted		147
Cyst (sebaceous)		3
Herpes of concha		1
Adenitis—		
postauricular	1	
preauricular	1	
submaxillary	1	
		3
Mastoiditis—		
acute, unilateral, right	3	
left	3	
chronic, unilateral, right	1	
left	2	
		9
Postoperative mastoid wounds from other hospitals for dressings		7
Foreign body in the external auditory canal		3
Otalgia from bad teeth		5
Nose cases:		
Deviation nasal septum		331
Congenital atresia (septum and turbinates)		1
Perforation, septum, traumatic	6	
specific	3	
		9
Spurs		19
Ulcers		14
Fractures, septum		6
Rhinitis—		
acute		46
with sinusitis, acute—		
frontal, right	30	
left	20	
antrum, right	8	
left	4	
ethmoid, right	5	
left	6	
		73

IN OUT-PATIENTS' CLINIC—continued.

Nose cases—Continued.		
Rhinitis—Continued.		
chronic, hypertrophic		53
with polypi		7
with sinusitis chronic		11
vernal catarrh		4
atrophic—		
specific (Wassermann)		1
nonspecific		21
Epistaxis		15
Fractures through frontal sinus		1
nasal bones		5
Abscess ala nasi		6
Throat cases:		
Tonsils—		
tonsillitis, acute	49	
abscess of	6	
		55
tonsillitis, chronic—		
hypertrophic	102	
infected	36	
with adenoids	18	
		156
lingual tonsil hypertrophy		1
Uvula elongated		4
Pharyngitis, acute	55	
chronic	16	
		71
Vincent's angina		8
Laryngitis, acute	39	
chronic	10	
specific	1	
tubercular (ulcer)	2	
		52
Aphonia, paralytic	3	
acute congestive	1	
hysterical	4	
		8
Lingual varix		1
Foreign body in the larynx (dental burr)		1
Epiglottiditis, chronic		1
Mucous patches uvula, soft palate, etc		1
Foreign body in the esophagus (dental burr)		1
Total number of cases		1,897

TABLE 14.—*Diseases treated and operations performed in ear, nose, and throat clinics, Base Hospital, Camp Merritt, N. J., February 19 to December 31, 1913, inclusive*—Continued.

CASES ADMITTED TO HOSPITAL.

Ear cases:		
Otitis media, acute purulent		64
with mastoiditis		84
Otitis media chronic purulent for S. C. D		47
Otitis media chronic catarrhal with defective hearing S. C. D		48
Infected postmastoid scar		1
Otitis externa		14
Aural polypus		1
Cerumen, impacted		1
Specific labyrinthitis (cerebrospinal syphilis)		1
Otosclerosis with labyrinthine symptoms, severe		2
Total deafness following mastoidectomy at another hospital		1
Nose cases:		
Deviated nasal septum for operation.		102
Abscess of the septum		1
Rhinitis, acute		1
chronic atrophic for S. C. D.		4
sinusitis, acute, frontal, right	8	
left	13	
ethmoid	8	
antrum	4	
chronic	7	
	—	40
Furuncle, ala nasi		1
Nasal polypi for operation		7
Cystic turbinate for operation		1
Fractures nasal bones		3
Epistaxis severe		3
Throat cases:		
Tonsillitis, acute follicular		9
Abscess, peritonsillar		6
Tonsillitis, chronic hypertrophic for tonsillectomy		229

CASES ADMITTED TO HOSPITAL—continued.

Throat cases—Continued.		
Laryngitis from gas	4	
acute	4	
chronic	3	
tuberculous	1	
	—	12
Pharyngitis, acute		7
Postpharyngeal abscess		1
Papilloma vocal cord		1
Aphonia with chronic laryngitis.	1	
hysterical	2	
	—	3
Stomatitis specific (mucous patches).		1
Adenitis cervical with abscess formation		1
Total number of cases admitted		697

OPERATIONS.

Mastoidectomy	84
Jugular ligation (lateral sinus thrombosis)	2
Tonsillectomies	235
Submucous resections	81
Incision furuncle ala nasi	1
Ethmoidal operation	4
Cervical abscess	3
Postauricular abscess	1
Nasal polypi	5
Turbinectomy	9
Removal cyst right frontal sinus (myxoma)	1
Tracheotomy	1
Total	427

TABLE 15.—*Diseases treated and operations performed in ear, nose, and throat clinics, Base Hospital, Camp Wheeler, Ga., Oct. 17, 1917, to March 6, 1919, inclusive.*[5]

CASES TREATED.	
Otitis media, acute suppurative	351
Otitis media, chronic suppurative	282
Otitis media, acute nonsuppurative	128
Otitis media, chronic nonsuppurative	118
Impacted cerumen	102
Nerve deafness	59
Salpingitis, acute	20
Salpingitis, chronic	17
Otosclerosis	59
Furunculosis	15
Rhinitis, acute	75
Rhinitis, chronic	72
Epistaxis	32
Deviation of nasal septum	165
Adenoids, hypertrophied	7
Ethmoiditis, acute	11
Ethmoiditis, chronic	25
Frontal sinusitis, acute	105
Frontal sinusitis, chronic	14
Acute follicular tonsillitis, bilateral	295
Chronic follicular tonsillitis, bilateral	203
Acute follicular tonsillitis, unilateral	7
Chronic follicular tonsillitis, unilateral	5
Tonsils, hypertrophied	54
Ozena	10
Laryngitis, acute	104
Laryngitis, chronic	45
Pharyngitis, acute	152
Pharyngitis, chronic	31
Syphilis	39
Aphonia	3
Total	2,605
OPERATIONS.	
Mastoidectomy	77
Frontal sinusitis, chronic	8
Empyema maxillary sinus	10
Radical operation on antrum	1
Tonsillectomy and adenectomy	3
Submucous resection, septum	64
Tonsillectomy	252
Turbinectomy	59
Nasal polyp removed	16
Peritonsillar abscess (incision)	12
Postoperative tonsillar hemorrhage	1
Fracture nasal process, superior maxillary	6
Myringotomy	105
To relieve tongue-tie	1
Adenectomy	5
Partial uvulotomy	2
Total	622

In addition to the above, 1,197 examinations were made and 12,708 treatments given in cases in which the diagnosis is not specified, making a total of 17,132 patients examined and treated in the ear, nose, and throat department of the Base Hospital at Camp Wheeler since its establishment.

The table which follows was prepared in the Statistical Division, Surgeon General's Office.[1] While, for the reason stated on page 744, it does not include all cases which actually occurred, it is of value in that it shows the relative primary admission rates for officers and white and colored enlisted men.

TABLE 16.—*Diseases and defects, ear, nose, and throat, officers, and white and colored enlisted men—Ratio per 1,000 of strength of primary admissions.*

	Officers.	White enlisted men.	Colored enlisted men.
Otitis media	5.32	12.03	5.88
Mastoiditis	.30	.54	.25
Otitis externa	.31	.36	.09
Defective hearing	.18	.19	.25
Ear, other diseases of	.25	.43	.34
Adenoids	.27	.36	.09
Deviation of nasal septum, and spur	7.81	3.29	.22
Turbinates, hypertrophy of	.55	.28	.03
Sinusitis (all)	4.76	2.22	1.87
Polypus, nasal	.31	.17	.11
Perforated nasal septum	.02	.01	.01
Rhinitis (cause not stated)	13.40	15.89	9.91
Nasal fossæ, other diseases of	1.83	3.90	6.32
Laryngitis, acute catarrhal	6.23	5.69	2.77
Larynx, other diseases of	.02	.02	.05
Tonsillitis, acute	42.46	65.87	43.19
Tonsillitis, chronic	19.94	9.49	3.34
Tonsils, focal infection from	.25	.07	.11
Pharyngitis, acute catarrhal	16.99	19.66	14.00
Pharynx, other diseases of	2.67	1.47	.65

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(1) Statistical tables compiled in the Statistical Division, Surgeon General's Office. On file, Historical Division, S. G. O.

(2) Report on otolaryngology, by Capt. Jacob W. Clark, M. C., Feb. 10, 1918. On file, Record Room, S. G. O., 730. (Otolaryngology) Camp Custer (D). Report on otolaryngology, by Capt. Samuel Iglauer, M. C., Dec. 18, 1918. On file, Record Room, S. G. O., 730. (Otolaryngology) Fort Sill (N). Report on otolaryngology, by Maj. Frederick D. Owsley, M. C., Dec. 1, 1918. On file, Record Room, S. G. O., 730. (Otolaryngology) Camp Jackson (D). Report on otolaryngology, by Capt. Stanley S. Burns, M. C., May 9, 1918. On file, Record Room, S. G. O., 730. (Otolaryngology) Camp MacArthur (D). Report on otolaryngology, by Capt. Henry Bierman, M. C., Feb. 11, 1919. On file, Record Room, S. G. O., 730. (Otolaryngology) Camp Sheridan (D). Report on otolaryngology, by Maj. Christian R. Holmes, Dec. 31, 1918. On file, Record Room, S. G. O., 730. (Otolaryngology) Camp Sherman (D). Report on otolaryngology, by Lieut. Col. J. H. Stearns, M. C., March 6, 1919. On file, Record Room, S. G. O., 730. (Otolaryngology) Camp Wheeler (D). Report on otolaryngology, by Lieut. Col. Thomas J. Harris, M. C., Jan. 16, 1919. On file, Record Room, S. G. O., 730. (Otolaryngology) G. H. No. 14 (K). Report on otolaryngology, by Maj. Francis E. Gessner, March 17, 1919. On file, Record Room, S. G. O., 730. (Otolaryngology) Fort Sam Houston (N). Report on otolaryngology, by Maj. Ernest F. Krug, M. C., Feb. 1, 1919. On file, Record Room, S. G. O., 730. (Otolaryngology) Camp Merritt (C).

(3) Report on otolaryngology, by Maj. Christian R. Holmes, M. C., Dec. 31, 1918. On file, Record Room, S. G. O., 730. (Otolaryngology) Camp Sherman (D).

(4) Report on otolaryngology, by Maj. Ernest F. Krug, M. C., Feb. 1, 1919. On file, Record Room, S. G. O., 730. (Otolaryngology) Camp Merritt (C).

(5) Report on otolaryngology, by Lieut. Col. J. H. Stearns, M. C., March 6, 1919. On file, Record Room, S. G. O., 730. (Otolaryngology) Camp Wheeler (D).

CHAPTER III.

DISEASES AND DEFECTS OF THE NOSE AND NASAL FOSSÆ.

The diseases and deformities of the nose and nasal fossæ which were encountered in the otolaryngological services of the base and general hospitals were, for the most part, similar in character to those seen in males of the same age period in civilian clinics. The number of cases treated in the military hospitals was probably proportionately greater than in civil institutions, as the soldiers often appeared at sick call with complaints for which, in their normal life, they would not have consulted an otolaryngologist. In addition, during the epidemics of the acute infectious diseases which appeared in many camps in the early days of the war, constant inspections of the troops were required and many soldiers with nasal infections and deformities were detected and ordered to report for treatment who would not have reported of their own volition. Many men with marked abnormalities of the nasal fossæ were accepted for military service who, in civil life, had experienced little inconvenience from the defects. The rigors of military training, however, often accentuated the effects of such conditions to a point where relief was necessary. Deviated septums, nasal spurs, and hypertrophied turbinates were marked examples falling under this head.

The number of submucous resections varied greatly in different camps, probably depending to some degree on the individual views of the otolaryngologists regarding the advisability of this operative procedure. The operation, however, was performed only when there was a marked occlusion of the nasal fossa, or where removal of the septum was necessitated by an accompanying sinusitis. In most hospitals this operation was performed under local anesthesia, usually cocaine or novocaine, the standard technique being followed. Among the complications noted as following this operation were fever, hematoma between the flaps, hemorrhage (primary and secondary), sinusitis, acute suppurative otitis media, acute mastoiditis, acute follicular tonsillitis, and perforation of the septum. The results of the operation in practically all cases were excellent, and no reports respecting deaths attending the operation have been found.

An interesting observation made at the Base Hospital, Camp Meade, Md., in reference to tonsillitis following submucous resections, was included in the report from that hospital as follows:[1]

> It was found essential to keep all the acute infections, especially tonsillitis, separate from the operative cases, and especially the submucous resections. For this reason all cases of tonsillitis, quinsy, and other acute infections of the upper respiratory tract, with the exception of sinus disease, were sent to medical wards, and during the winter months there was one ward devoted entirely to this class of cases. In spite of all precautions, occasionally an acute case of tonsillitis would get into the operative ward, and almost invariably tonsillitis would develop in more than 50 per cent of the submucous resections. Considerable bacteriological investigation was undertaken to determine, if possible, the etiology of tonsillitis following this operation, but the only stable factor that could be found was that cases just operated on for submucous resection of the nasal septum were especially susceptible to tonsillar infection, which infection, however, must originate from more or less intimate contact with a case of acute tonsillitis, though one epidemic did follow the admission to the ward of a case of hemolytic streptococcic mastoiditis.

The total number of turbinectomies was small, only a few of interest having been reported. A case of unusual interest observed at General Hospital No. 14 is reported in full:[2]

The patient, a young student officer, was first seen May 29, 1918. He was to all appearances a healthy man of 26 or 27 years. He gave a history that a number of years ago he had sustained, in the course of a football game, a fracture of the nose. This incapacitated him for two weeks, since which time, 12 or more years ago, his nose had given him no trouble. In the course of a routine examination of the nose and throat an obstructing growth in the right nostril was discovered. When his attention was directed to it, he admitted that the breathing on that side was considerably obstructed. He made no complaint of headaches and there were no signs of disease of the accessory sinuses. Examination of the nose showed a large mass, having its origin apparently in the middle meatus, of sufficient size to interfere decidedly with respiration. It gave at first the appearance of an ordinary nasal polyp. More careful examination showed it to be the middle turbinate which had undergone cystic degeneration. Palpation with a probe gave the sensation of semi-density. The inferior turbinate was decidedly atrophic. The cyst under strict aseptic precautions was aspirated and a small quantity of clear fluid was withdrawn. This was sent to the laboratory for examination. The sensation of penetrating a thick but resisting wall was met with in the introduction of the needle.

The patient was seen the following day and had experienced no unpleasant results from the examination. The report of the laboratory of the cyst's contents was negative. Removal of the cystic turbinate was recommended and agreed to.

The patient was admitted to the hospital Monday, June 3, and was operated upon the same day. Extreme care was exercised so far as asepsis was concerned. Local anesthesia (application of 20 per cent solution of cocaine by packing) was employed. The duration of the operation was from two to three minutes. Convalescence was uneventful; there were no after symptoms, no headaches, no fever, no discharge. The patient was dismissed from the hospital the third day with instructions to report the following day for examination. He was seen the following day. His nose was in perfect condition, subjectively and objectively. No treatment was given. He was again seen Saturday, June 7, and was feeling perfectly well. A slight bleeding from the operated side of the nose had taken place, which the patient ascribed to an examination at the infirmary. A small spot regarded by him as the cause of the bleeding had been touched by a solution of nitrate of silver. Examination showed the nose virtually well. The patient was discharged with the request to report the middle of the following week for final examination.

An X-ray picture was taken Saturday, June 7, showing complete absence of both frontal sinuses and granulations in the right ethmoid.

Sunday, June 8, he was seen in his quarters, about 8 o'clock, complaining that he had been suffering from headache all night. It was learned that the previous afternoon he had attended a baseball game. At 4 o'clock he vomited. He was aroused with some difficulty and was clearly very sick. He was ordered to the hospital without delay.

A spinal puncture was performed showing a decidedly cloudy fluid. There was a positive Kernig. A diagnosis of meningitis was made. He became rapidly more comatose until, when seen at 2 o'clock, he was in deep coma. He died without regaining consciousness Monday night at 10.30 o'clock.

An autopsy was performed, the report being as follows: Cause of death: Meningitis, cerebrospinal, acute fibrino-purulent, pneumococcic. Contributory: Cystic degeneration middle turbinate, with operation complicated by a failure of formation, cribriform plate, ethmoid bone, right. Bacteriological diagnosis: Pneumococcus. The brain: The skull was opened by the usual incision. Upon lifting off the calvarium, a profuse exudate was noted over the convex surface of the cerebrum, more marked on the right side than on the left. The exudate occupied the subdural and pia arachnoid spaces and was more fibrinous than purulent. This follows the usual course of an exudate developed by this type of pneumococcus with chemotropic repellant action. The exudate was quite extensive over the entire brain, the base as well, and quite blocked up the cisterna magna. The smaller capillaries of the pia were extremely congested and in places showed small hemorrhagic areas.

The spinal cord was not removed, but the exudative process extended along the cord below the pons.

In removing the brain it was noted that the anterior lobe of the cerebrum was adherent to the cribriform plate of the ethmoid on the right side. Some of the brain structure was torn during the removal. This would indicate that at least part of the process at this point was chronic. In the middle portion of this cribriform plate just to the right of the crista galli an opening was found about 5 mm. in diameter, with a necrotic center. This necrosis included the dural covering. It was possible to pass a pair of forceps straight through into the nasal cavity. Thus a direct communication was established between the ethmoid sinus and dural space. Upon stripping the dura, the opening in the bone was found to be perfectly smooth and regular and without reaction in the bone about the hole in the plate on this side. After removal of the plate, the underlying ethmoid cells were found as a mass of necrotic material attached to the plate above and opening into the nasopharynx below.

The nature of the opening in the cribriform plate had several possibilities. The regular and smooth appearance associated with depression suggests a possibility of a developmental fault. On the other hand, the necrotic character of the ethmoid cells strongly suggests an extension of the inflammation as an osteitis. The history of an old fracture of the nose is in favor of the latter conclusion.

Bacteriological study of the exudate shows the infecting organism to be pneumococcus.

A smear was taken from the nose at the time of the operation and showed many Gram-negative and Gram-positive diplococci.

Specimen from spinal fluid showed pneumococci, Type II (atypical).

Specimen from autopsy showed pneumococci, Type II (atypical).

The tissue removed from the nose was submitted for examination.

The laboratory report follows:

Gross: The tissue submitted consists of a small mass of mucosa and submucosal tissue.

Microscopical: Three blocks of tissue were cut. The sections showed the mucosa and submucosa the seat of an intense inflammatory process. In some places the modified epidermal layer has been lost as if by ulceration. The blood vessels are decidely congested and the lymph spaces are filled with an exudate. The cellular exudate was made up of polymorphonucular leucocytes with large numbers of plasma cells. In addition to the acute process, there is evidence of an old chronic inflammatory lesion as evidenced by heavy strands of connective tissue in the submucosal position.

The diagnosis is based on the tissue as submitted:

Diagnosis: Rhinitis, acute phlegmonous, superimposed upon rhinitis, chronic hypertrophic.

Comment: There is little question that the perforation in the plate had existed since the time of the injury to the nose 12 years before.

In spite of the absence of symptoms, there was clearly present an old ethmoiditis, latent in character, associated with a latent meningitis. There was probably a direct communication between the cystic turbinate and the brain. As was stated by one of the surgeons who saw the case, the slightest shock was sufficient to light up the inflammation. The operation, slight as it was, served as the exciting cause.

A case quite similar to the above was seen in the Base Hospital, Camp Lee, Va. The patient had a chronic ethmoiditis with polyps, pus, and headache. The polyps were removed and an attempt was made to discover ethmoid cells without success. Meningitis developed in the course of a week, with death. The autopsy revealed an old necrotic cribriform plate and a probable localized meningitis existing before the operation. In the opinion of the operator the operation had broken down the walled-off area and had permitted the development of a general infection.

Comparatively few cases of sinusitis were noted in the reports received and the relative proportion of cases in which the different sinuses were involved can not be determined. From the statements made in a later chapter in connection with the nasal complications of influenza, as revealed at autopsy, it is evident that many cases of sinusitis were unrecognized during life, owing to the mildness of the symptoms.

Operative procedures were undertaken in these cases when indicated, the character of the operation usually depending on the personal preference of the chief of the service. In considering frontal sinus operations the chief of the head surgery section, Base Hospital, Camp Dix, N. J., remarked: [3]

A number of frontal sinus operations were performed, the majority of them with complete primary closure of the wound, with uniformly successful results, and persuaded the chief that an external operation, if aseptically conducted, should always be the operation of election. He has definitely discarded all intranasal operations for frontal sinus diseases, as with proper technique no deformity whatever results and the secondary infection from the nose is avoided.

The following is an extract of a report from the Base Hospital, Camp Taylor, Ky.: [4]

Chronic sinusitis was surprisingly frequent, considering the fact that the majority of the patients were between the ages of 21 and 23 years. Most of these came to the department complaining of vague pain in the head, chronic nasal discharge, eye disturbances, or some chronic secondary infection. In all cases careful intranasal examination, transillumination, X-ray and, wherever possible, diagnostic puncture, were done, and at times prolonged irrigation treatment before operation was decided upon. No more satisfactory results were obtained in any condition, however, than in these cases. We are led to believe from observation that many cases of sinus infection have been overlooked.

An unusual and interesting case of ethmoiditis with postoperative complications was observed at the Walter Reed General Hospital: [5]

The patient, a private of Engineers, was admitted on June 3, 1918, complaining of almost complete obstruction of the right nostril, dull headaches, and excessive discharge from the right side. Examination showed multiple polypi in both sides of the nose, tenderness on pressure over the inner angle of the supraorbital ridge and corresponding ethmoid region. X-ray examination showed cloudiness of all sinuses on the right.

On June 10 the polypi from both sides of the nose were removed. The nose was irrigated and from time to time recurring polypi were removed. On July 16, under local anesthetic, the whole of the right middle turbinate and numerous polypi were removed, together with a complete curettage of all the ethmoid cells. The following morning there was some swelling of the upper and lower lids on the right, and ecchymosis of the conjunctiva. Swelling of the lids became more pronounced daily, the movements of the eye were painful, and nasal irrigation brought away a large quantity of foul-smelling pus.

On July 22 a free incision was made through the swelling in the lower lid and a large quantity of foul pus evacuated. A gauze drain was placed in the wound. After this the swelling of the lids subsided rapidly, and irrigations through the orbital incision passed freely into the nose through the middle ethmoid region. Vision in eye was greatly reduced, the patient having only light perception. The nose and orbital wound were irrigated daily with normal saline solution and in about two weeks, all pus formation having ceased, the wound was allowed to close. The vision again became normal. Patient made a complete recovery and was returned to duty.

The following case, similar to the foregoing, was reported from the Base Hospital, Camp Jackson, S. C.: [6]

Sgt. J. M. S. During the past year patient had had several attacks of pain in left frontal region. About July 15, he noticed pain and swelling at inner angle of left orbit. This continued until August 16, when he came to the clinic. At that time the anterior end of the left middle turbinate was removed for drainage. Swelling at the inner canthus of the left eye continued, until two days later, when ecchymosis of the eyelids appeared. On August 19 the anterior ethmoidal cells, left side, were opened intranasally. Twelve hours later the swelling of the lids and periorbital tissues increased rapidly, pain was present back of the eyeball, but the tenderness at the inner canthus disappeared, the eyeball itself began to protrude, and chills and fever were present, temperature of 102½. On August 20 an external operation was done. A curved incision about the inner brim of the orbit was made and the periosteum elevated. At the roof of the orbit, 1¼ inches back of the bridge of the nose, was an abscess, back of which was a necrotic opening, opening from an ethmoid

cell into the orbit. A complete exenteration of the anterior ethmoid cells was made. Gauze drainage was placed from the sinus down into the nares, tube drainage was placed externally. After operation there was a free drainage of pus both intranasally and externally, but the edema and exophthalmos did not subside. On August 24 there was indication of pointing at lower angle of the orbit; vision remained good. On August 25 distinct pointing at the lower angle of the orbit. An incision was made through the skin into a superficial orbital abscess. About a dram of pus was evacuated The edema and exophthalmos immediately began to subside and the patient has improved daily. Has had no temperature since external operation, August 20. Present condition of eyelids slightly edematous. Eyesight normal. Owing to such a general periorbital cellulitis and infection, external drainage has been continued.

Many cases of fracture of the nasal bones were treated in the various clinics, and a certain amount of transplantation of bone and cartilage for the correction of sunken noses was done.

With the return of wounded soldiers from abroad, there came a number of men with marked deformities, the results of gunshot wounds of the nose and sinuses. Upon admission to hospitals in this country these patients chiefly required plastic operations for the correction of the deformities. While this work was done by maxillofacial specialists, otolaryngologists were often consulted in cases where their special knowledge was of value.

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CHAPTER IV.

DISEASES OF THE THROAT.

PHARYNX.

Among troops serving in the United States there were 42,811 primary admissions to sick report on account of acute catarrhal pharyngitis, and in approximately 4,500 cases this disease was recorded as a secondary diagnosis in men who had been admitted originally for some other disease.[1] The diseases with which acute pharyngitis was most frequently associated secondarily were measles, influenza, mumps, acute articular rheumatism, gonococcus infection, otitis media, rhinitis, acute tonsillitis, and bronchitis. As in many of the above diseases in which pharyngitis was recorded as a secondary disease, the pharyngitis was either a symptom of the primary condition or was associated with the disease first recorded, it is evident that some confusion existed among medical officers in recording pharyngitis as a complication. If an existing pharyngitis had been separately recorded in all cases as a complication of the primary diseases mentioned, the total occurrence of pharyngitis would have been much greater than these statistics show.

In cases where the diagnosis of acute catarrhal pharyngitis was primarily made, a secondary diagnosis was recorded approximately 4,500 times.[1] Prominent among the secondary diagnoses of record are influenza, scarlet fever, carrier of diphtheria bacilli, mumps, acute articular rheumatism, tuberculosis of lungs, otitis media, deviated nasal septum, laryngitis, rhinitis, tonsillitis, suppurative pleurisy, bronchopneumonia, and bronchitis. In many of the above diseases it is probable that on admission the only symptom apparent was the pharyngeal inflammation, which was a prodrome of the secondary disease, definite symptoms of which shortly appeared. Of some interest are the diphtheria-carrier cases. Only thirty-three men were admitted for acute pharyngitis who, during their stay in hospital, were found to be harboring diphtheria bacilli in the upper respiratory tract.

TONSILS.

Acute tonsillitis was responsible for 141,067 primary admissions to sick report in this country from April 1, 1917, to December 31, 1919, inclusive.[1] In addition, this disease was recorded as a secondary diagnosis in approximately 8,750 men who had been placed on sick report for other diseases. In this series the diseases with which acute tonsillitis was most frequently associated were measles, influenza, mumps, arthritis, otitis media, acute pharyngitis, and acute bronchitis.[1]

There were 21,618 primary admissions for chronic tonsillitis and about 7,020 cases in which this disease was associated with some other primary cause of admission for disease. Among the primary diseases with which chronic tonsillitis was noted were arthritis, otitis media, and deviated nasal septum.[1]

Of the patients admitted to sick report with a primary diagnosis of acute tonsillitis approximately 9,000 had a secondary or intercurrent disease recorded. Most frequent among the diseases noted were otitis media, adenoids, sinusitis,

arthritis, pharyngitis, and bronchitis. One hundred and seventy patients admitted to hospital with acute tonsillitis were found to be carriers of diphtheria bacilli.[1]

Adenoid disease was noted as a secondary diagnosis in practically one-third of all cases admitted to sick report with a diagnosis of chronic tonsillitis.[1]

The reports from the various hospitals make no mention of any facts of special clinical importance having been observed in this large series of cases, save that in several instances acute follicular tonsillitis developed serious complications. Arthritis following the tonsillar infection was of comparatively frequent occurrence and several cases were noted where an acute tonsillitis seemed responsible for a subsequent empyema. The question naturally arises as to the extent to which such diseases would have occurred had the tonsils been previously enucleated. The chronic infected tonsils, of course, played an important rôle as a causative factor in a variety of diseases.

No accurate records are available as to the exact number of tonsillectomies performed. A study of the tables given in Chapter II shows the number to have been large. It must not be presumed that all of these operations were done on the initiative of the otolaryngologists, as many cases were operated at the request of the medical services of the different hospitals, to remove foci of infection which were regarded as responsible for numerous other diseases.

The operative technique which was used depended on the personal preferences of the individual operator. In general, local anesthesia was employed and the tonsil was enucleated by some modification of the dissection and wire-snare method.

A study of 31 cases of postoperative complications of tonsillectomy was made at the Base Hospital, Camp Lewis, Wash., and the following report submitted:

TABLE 17.—*Tonsillectomy: Postoperative complications in 31 cases, Base Hospital, Camp Lewis, Wash.*[2]

Reg. No.	Hemorrhage.			Infection.	
	Moderate.	Excessive.	Time after operation.	Manifested by—	Time after operation.
21046		+	At time of operation		
21264	+		do		
22513	+		10 hours		
22901	+		On day of operation		
25465	−		4 and 5 days		
25396				+Fever	2 days.
21533	+		12 hours		
23268	+		36 hours		
24387				+Stiffness of neck	3 dys.
25139	+		36 hours		
16735		−	At time of operation		
25093	+		2 hours		
22856	+		1 hour		
9044	+		2 hours		
7505	+		6 hours		
6071				+Abscess	7 days.
5983	+		At time of operation		
8522				+Swelling and pain	4 days.
8801				+Abscess	6 days.
7728				+Not recorded	7 days.
7361				+Abscess	13 days.
7388	+		48 hours		
17371	+		12 hours		
10483		+	3 hours		
15431	+		8 days		
19085		+	6 hours		
16519	+		4 days		
18071		+	2 days		
28316		+	11 hours		
32471				+Adenitis	3 days.
31299		+	2½ hours	+Abscess	15 days.

From this table it will be seen that only seven cases of hemorrhage were considered excessive and that there were no fatal cases.

Hemorrhage may be arbitrarily divided into (1) primary—at time of operation; (2) delayed primary—within 12 hours after operation; (3) secondary—after 12 hours after operation.

Of the above cases 4 were primary, 10 were delayed primary, 9 were secondary. The methods used to control bleeding were cold, pressure, suture, and clamp.

One of the cases of secondary hemorrhage followed the adenoidectomy, although both adenoidectomy and tonsillectomy had been performed. The bleeding was apparently from the posterior surface of the soft palate, was very profuse, and was controlled only by postnasal plug after all other methods had failed.

The method of operating in all cases was by dissection and snare. No special cause for hemorrhage could be determined, although some operators seemed to have relatively more cases than others.

Infection was manifested by rise of temperature, stiffness of the neck, and abscess. There were no fatalities.

The chief of the ear, nose, and throat service at the Base Hospital, Camp Dix, N. J., submitted the following report relative to tonsil operations:[3]

Two cases of deep abscess of the neck several weeks after the removal of diseased tonsils under local anesthesia (one case having been operated on at another camp) raises the question of the danger of local infection through the diseased area of the tonsil into the tissue beyond the tonsil capsules, the experience of the chief of the section being that all neck infections, no matter how slight, which may follow a tonsil operation under ether are avoidable by proper technique. The reaction following enucleation under local anesthesia is certainly greater than under general anesthesia. Two cases developed pneumococcic infection following enucleation of the tonsils under general anesthesia, believed to be the same cause of the pneumonia following the nasal fracture operation, viz. cold halls and wards and the prevalence of the streptococcic infection to which the men were not immune. In the opinion of the chief, the pneumonia was preventable if the patients could have been kept at uniform temperature following the operation. That the etiology of the pneumonia was practically the inhalation of the ether is shown by the fact that no pneumonia occurred after local anesthesia.

In view of the numerous cases of acute infectious diseases (especially those belonging to the respiratory group) which prevailed in many of the camps during the early days of mobilization, extensive studies were initiated at several of the base and general hospitals to determine the extent to which carriers were responsible for the spread of these diseases and the anatomical parts of the carriers which the organisms most frequently made their habitat. These studies related especially to diphtheria and cerebrospinal meningitis. It was almost universally determined that the tonsils were the organs most frequently found infected, and that in the majority of cases the carriers were sterilized after tonsillectomy had been performed.

The following extract from a report published by medical officers on duty at Camp Doniphan, Okla., where a severe diphtheria epidemic had existed, shows the excellent results attained following tonsillectomy in carriers:[4]

Since local applications have proved unreliable in the treatment of the carrier state, it seems to us that operative interference is the only solution of the problem, especially in those cases in which the tonsils can definitely be shown to be the focus of infection. In 77.2 per cent of carriers the bacilli were harbored in the tonsils. The majority of the remainder showed the presence of *B. diphtheriæ* in the nose.

The tonsils should be removed in every case in which it can be positively demonstrated that they are harboring the organism. The contraindications for tonsillectomy in carriers are those that apply under other circumstances.

The majority of patients with clinical diphtheria remain in the hospital for a period of approximately four weeks before they are returned to their commands. Since, in the average

case, the bacilli have disappeared by the end of the third week, this may be taken arbitrarily as the beginning of the carrier stage. Consequently, it is safe to remove the tonsils at this time, provided there are no contraindications.

The reaction in carriers, following operations, does not differ from that found in noncarriers. Occasionally it may be severe enough to arouse suspicion that clinical diphtheria is present. However, unless there has been operative traumatism to the surrounding structures, the limitation of the postoperative exudate to the tonsillar fossæ—in contrast to the angry red, edematous throat of diphtheria, in association with the marked prostration—suffices to differentiate the two conditions.

Patients on whom operations were performed had been positive for a period varying from one week to several months. As nearly as could be determined, the proportion of primary to secondary carriers was as 2 : 1. Of the 294 carriers operated on, 20 per cent yielded a positive culture from the nose and 57 per cent from the throat immediately before operation. Subsequent to operation the following results were obtained: Ninety-four, or 32 per cent, had no positive returns; 136, or 46.4 per cent, were negative by the end of the first week; 38, or 12.9 per cent, were negative by the end of the second week; 11, or 3.7 per cent, were negative by the end of the third week; 14, or 4.7 per cent, were negative by the end of from four to eight weeks; 1, or 0.3 per cent, was still positive at the end of four months, despite all treatment.

In another report from Camp Doniphan it is stated that the carrier situation was of considerable interest. One meningitis carrier in whom the carrier condition was localized in the nasopharynx was operated upon. Something over 300 diphtheria carriers were operated upon, about 92 per cent of whom were negative at the end of the first week.

The number of infections appearing throughout the country, for which the hemolytic streptococcic group of organisms was responsible, prompted a study at the Walter Reed General Hospital of the tonsils as the foci for this organism. The following data are extracted from the report of this investigation: [5]

The study of hemolytic streptococcus infections, which has been stimulated by the Army experiences of last winter, naturally includes the subject of carriers. We have done some work in this field and are convinced that the tonsils play a part which should be emphasized. It has already been shown that throat swab cultures demonstrate the presence of hemolytic streptococci in various percentages of individuals and that hemolytic streptococcus complications, for example, in measles, occur only in those with positive throats. Throat swab cultures for hemolytic streptococci therefore have a practical value in the maintenance of clean and infected wards which has been confirmed by experience at this hospital.

With the established importance of positive throat cultures as a starting point, our attention was directed toward localizing the focus of infection if there is one. For this purpose we made swab cultures in positive throat cases from the saliva. In making the nasal cultures, the swabs were passed into the nasopharynx. The results were striking. The cultures of nasal swabs were either negative or showed a few hemolytic streptococcus colonies, the pharynx cultures were moderately positive, those of the saliva slightly so, but the tonsil cultures showed in every case a rich growth of hemolytic streptococci. In the isolation and identification of hemolytic streptococci the methods adopted by the Medical Department of the United States Army were followed.

These results pointed to the tonsils as possible foci of infection. One hundred pairs of excised tonsils were then examined by means of crypt cultures made with a platinum loop. Seventy-five pairs were found positive. The degree of infection in one or both tonsils of each pair was as follows:

Pure hemolytic streptococcus....per cent..	31
Predominating....do....	23
Many hemolytic streptococcus....do....	16
	70
Few hemolytic streptococcus....	5
No hemolytic streptococcus....	25

These tonsils were removed on clinical grounds on account of size, presence of discharge from the crypts, cervical glandular enlargement, and possibility of focal infection, and not on account of the carrier state, except in a few instances. The results of this series of examinations made it clear that diseased tonsils harbor hemolytic streptococci in a large proportion of cases.

The change noted in throat cultures after tonsillectomy was striking as compared with any other method. Twenty-seven of 31 cases showed a second consecutive negative culture in 11 days. The cases which did not clear up under tonsillectomy had foci in the nose or gums and became negative when these were corrected. No case of a carrier has been found in men who had previously had their tonsils properly removed.

LARYNX.

There were 12,360 cases in which acute catarrhal laryngitis was recorded as the cause of primary admission to sick report among the troops on duty within the United States, and in 2,450 it was recorded as the secondary diagnosis among soldiers, already on sick report, who had been admitted originally for some other disease.[1] Acute catarrhal laryngitis as seen in the Army differed in no respect from this disease in civil life and no mention was made in the reports received of any unusual manifestations.

The usual number of tumors of the larynx for men of the age group concerned was observed at the base and general hospitals, but no noteworthy features of this condition were reported. An interesting case of laryngeal ulceration is reported:[5]

Maj. F. E. B. was admitted to the Walter Reed General Hospital, October 8, 1918, with double pneumonia, following influenza. He was critically ill, but made a satisfactory recovery as far as his pneumonia was concerned. During his convalescence it was noticed that his voice became very husky and that he complained of pain in the region of the larynx, and pain referred to the ears. He was transferred from the Medical Service to the ear, nose, and throat section. On admission to this section his voice was raucous and there was some cough and pain in the larynx. Examination showed both tonsils hypertrophied, with some exudate from the cysts on pressure; smears showed positive streptococci. The larynx congested, the congestion extending well down into the trachea. There was a marked ulcerative condition noted along the free margin of the epiglottis, the free margin of the right vocal cord, over the processus vocales of the left vocal cord and near the apices of the arytenoid cartilages. The character of these secretions was unique in that the mucous membrane covering the cartilage was not actually broken through, but there was an undermining of the submucous tissue, leaving marked depressions with cup-shaped and everted margins. This was especially true along the margins of the epiglottis.

Another interesting feature of these depressions in the mucosa was that they were dry, no secretion whatever being in evidence, and that the mucous membrane had a highly glistening appearance which is quite unlike the usual forms of ulcerations met with in the larynx.

My first impression was that this patient was suffering from tuberculosis of the larynx, but upon further study concluded the ulcerations were of streptococcic origin. One point in favor of this view in making a differential diagnosis was the unbroken and dry membrane covering the depressions, whereas if the case had been tuberculous the membrane would have been broken and bathed with secretion.

A few days after his admission to the ear, nose, and throat section, an abscess developed in the left ear, and smears taken from the secretion showed the streptococcus to be the prevailing organism.

X-ray findings of the lung: All lobes are involved by this hemorrhagic pulmonitis and show a high degree of mottling. The picture is a true streptococcus type.

Laboratory findings: Tubercle bacilli, after numerous examinations, not found. Streptococcus the prevailing organism found in cultures from secretion from the tonsils and middle ear.

The tonsils, which may have been the primary source of the infection, were enucleated, with marked improvement in the patient's general and local condition.

One condition which was observed more frequently in the military service than is usual among men of the same age group in civil life was hysterical aphonia.

Hysterical manifestations of various types were not infrequent in the camps, so that it is not surprising that in a number of cases the vocal apparatus should have been the part involved. The otolaryngologist on duty at General Hospital No. 30, Plattsburg Barracks, N. Y., reported that as this hospital received only neurotic cases, hysterical aphonia was frequently encountered and was treated by persuasion and suggestion. Some of these patients entered the hospital with a record of having been treated in France, with no improvement, and they were very much discouraged, but with this simple treatment they were cured in a very short time.[6]

The chief of the otolaryngological service at General Hospital No. 3, Rahway, N. J., gave a record of four cases of aphonia whose period of illness varied from two to six months. All of these patients responded readily to suggestive therapy, proving that they were not subjects of organic paralyses. In civil practice one would have to see a great many laryngological cases before encountering four cases of hysterical aphonia in male adults.[7]

A report from the Base Hospital, Camp Lee, Va., includes 12 cases of aphonia following measles or influenza, all of these cases being in hysterical subjects, giving rise to the question of malingering. Abductor paralysis was present, but all showed a low grade laryngitis. After this was cured the introduction of a bronchoscope cured the hysteria in all but one case.

Very few gunshot wounds of the larynx required treatment after arrival in this country. Most of these cases were treated at General Hospital No. 11.[8] The chief of the throat service of that hospital reported 12 gunshot injuries of the larynx. In most of these cases the voice, of course, was materially interfered with, but the majority of them still had some voice better than a whisper. One of the difficult problems mentioned in this report in connection with these laryngeal cases is the cure of fistulæ leading directly into the larynx or along the lateral wall, which persisted on account of the slow improvement of the cartilage.

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CHAPTER V.

DISEASES AND INJURIES OF THE EARS.

EXTERNAL AND MIDDLE EAR.

OTITIS EXTERNA.

Otitis externa was reported in only a comparatively small number of cases, probably not requiring treatment as frequently as in civil life. The greatest number appeared as a complication of the influenza epidemic of 1918, often accompanying an inflammation of the middle ear. Nothing of unusual importance in reference to this condition was reported.

OTITIS MEDIA.

Of all diseases coming under the care of the otolaryngologist, otitis media was the one which assumed the place of utmost importance. The extensive epidemics of the acute infectious diseases, especially measles and influenza, which appeared in most of the camps, were responsible for the majority of the cases of acute otitis media. While chronic otitis media was prescribed as a cause of rejection for the military service, unquestionably many recruits were accepted who had this disease in a quiescent stage. The rigors and exposure of military life brought on a recrudescence of the disease to an extent which required treatment. Many more cases of otitis media were seen by the otolaryngologists in the Army than would have applied for treatment from the same number of men in their normal walks of life.

During the period of the war and demobilization of the Army there were 25,178 primary admissions to sick report in this country for otitis media and in approximately 11,000 cases this diagnosis was recorded as secondary to some other disease to which the original admission had been charged.[1] In these secondary cases measles was shown as the primary disease in about 2,700 instances and influenza in 2,300. The ratio in which otitis media accompanied these two diseases, as considered in relation to the total number of primary admissions for each was 40 per thousand for measles and 5 for influenza. The greater frequency with which otitis media was associated with measles than with influenza is clearly apparent.

The differentiation of the otitis media cases into acute and chronic was not made in the general statistical tables, but in a special table,[1] 2,015 cases are considered, of which 1,907 were acute and 108 chronic. The severe infectious diseases (notably measles, influenza, scarlet fever and diphtheria) were responsible for the great majority of the acute cases. Undoubtedly a certain number of men with chronic middle-ear suppuration were overlooked at the preliminary physical examination on entrance to the military service, and this class was mainly responsible for the chronic cases which required treatment.

Among the other diseases with which otitis media was most often associated were scarlet fever, mumps, acute and chronic tonsillitis, bronchitis, bronchopneumonia, and lobar pneumonia.

As would be expected, mastoiditis was the disease which most frequently appeared as a complication or sequela of primary cases of otitis media. Other diseases and defects which were frequently recorded as intercurrent with original admissions for otitis media were otitis externa, deviated nasal septum, sinusitis, rhinitis, acute and chronic tonsillitis, bronchitis, and bronchopneumonia.

The bacteriology of otitis media was extremely varied, following, in this respect, the inflammation of other portions of the respiratory tract. During the periods when the hemolytic streptococcus was present in many of the camps this organism played an important rôle. In this connection the Chief of Service at the Base Hospital, Camp Pike, Ark., reported that the most striking feature of the clinical work concerned the many and varied streptococcic infections which developed in this service. It was noted particularly that throat infections from which hemolytic streptococcic cultures were obtained were very liable to develop middle ear complications.

No clinical features were observed which differed from those ordinarily associated with otitis media. The peculiar characteristics of the disease, when it occurred as a sequela of influenza, will be noted later.

MASTOID.

MASTOIDITIS.

Eleven hundred and forty-one primary admissions for mastoiditis were recorded by the Statistical Division of the Surgeon General's Office as having occurred in the United States.[1] This number must represent only a proportion of the actual number of cases, as the majority appeared in men who had already been admitted to hospital with some other diagnosis which was recorded as the primary cause of admission. The exact number of secondary cases which occurred in this country is not known, but a safe estimate would be not less than 3,400 cases, making a total of approximately 4,500 cases of mastoiditis occurring among troops stationed in the United States.

The percentage of mastoid involvement when compared with the incidence of otitis media was considerably less than normally occurs in civil life. The patients with the infectious diseases (of which the ear diseases were complications) were under treatment in hospitals, and careful routine examinations were made of all ear involvement, immediate paracentesis being performed when indicated. Through this practice the extension of the infection to the mastoid was avoided in many cases.

The total number of mastoid cases which occurred was much greater than is ordinarily seen in civil hospitals and the opportunities for a study of this disease were probably better than any which had previously existed in even the larger civil hospitals. Numerous excellent reports were submitted from the various base and general hospitals regarding the observations made concerning the mastoiditis cases.

While certain observers expressed the belief that in some cases a direct involvement of the mastoid occurred from the nasopharynx or blood stream without involvement of the middle ear, the general consensus of opinion was that there had been invariably a preceding middle-ear inflammation, though in certain instances the invasion of the middle ear and mastoid had the appearance of being synchronous, so rapidly did the infection develop.

Of striking interest in the consideration of mastoiditis as it occurred in the various camps, is the rôle which the various microorganisms played as the causative factor of the infection. This subject was covered at length in many of the reports received. That a great divergence of opinion existed in this respect at the various hospitals and even, at different times, at the same hospital, is shown in the reports quoted below.

Type of Infection.

This question has been thoroughly considered in a report on meningitis prepared by the otolaryngological staff of the Base Hospital, Fort Riley, Kans., as follows: [2]

Locality infection.—By the term "locality infection" is meant the occurrence in a locality or Army post of a certain organism which is found to predominate, either singly or combined, in infections occurring in that particular locality or Army post. At one camp, for instance, the hemolytic streptococcus may be the organism found in the tonsil crypts in pneumonia, in mastoiditis, or in other diseases, while in another camp the pneumococcus or streptococcus viridans may be the prevailing organism. Any one of these organisms may become virulent for a certain period and then apparently become of little consequence. However, when an epidemic of tonsillitis, measles, scarlet fever, or influenza occurs, then the particular organism for a certain locality suddenly assumes the rôle of secondary invader and becomes the predominating factor in complications. That the temporary home for this locality-infectious organism is in the tonsil crypt is undoubtedly true, while the accessory nasal sinuses are at times the home of the organism.

The spasmodic appearance of a number of cases of acute mastoiditis is not surprising when one considers the above factors as noted in cantonments. During January, February, March, April, and May in 1918, the hemolytic streptococcus was the locality infection at Camp Funston. The number of pneumonias and mastoiditis cases (requiring mastoidectomies) was so great that one could speak of it as an epidemic. The organism which predominated in both series of cases was the hemolytic streptococcus occurring in 28.2 per cent of all pneumonia and 76 per cent of the mastoids (cultures from the mastoid cells at time of operation). The term streptococcus epidemic therefore is a better term.

In the recent epidemic of influenza in the same hospital, tissue cultures at necropsy showed the predominating organism again to be the hemolytic streptococcus. It was present singly or combined in 41.1 per cent of all tissue cultures, including the lung, pleural fluid, heart blood, spleen, nasal sinuses, mastoids, and spinal fluid. Blood-stream invasion occurred late in this series of cases.

From the above statements one must conclude that the occurrence of mastoiditis as seen in Army cantonments depends upon the surroundings of the individual and the presence of a virulent organism, such as the streptococcus or pneumococcus.

At the Base Hospital, Camp Shelby, Miss., the streptococcus viridans was the organism most frequently isolated in cultures from the pus evacuated from the mastoid cells. The chief of the otolaryngological service at the hospital summarizes and discusses this question in his report on mastoiditis in the table following.[3]

TABLE 18.—*Relation of antecedent diseases and the bacterial incidence among 123 cases of acute mastoiditis.*

Organism.	Cases.	Deaths.		Antecedent diseases.		
		Number.	Following—		Cases.	Deaths.
Streptococcus viridans	29	7	Measles 5 Measles and mumps 1 Otitis media purulenta 1	Measles	27	9
Streptococcus hemolyticus	5	3	Measles 1 Mumps 2	Respiratory diseases Otitis media purulenta	12 16	0 1
Streptococcus and staphylococcus.	17	1	Measles 1	Mumps Scarlet fever Erysipelas	2 1 1	2 0 0
Streptococcus and miscellaneous organanisms.	8	1	Measles 1 — 12		59	12
Staphylococcus aureus	13	0		Measles Respiratory diseases Otitis media purulenta Mumps	3 3 7 0 13	
Miscellaneous organisms	9	0		Measles Respiratory diseases Otitis media purulenta Mumps	2 3 3 1 9	
Culture negative or not taken.	42	0		Measles Respiratory diseases Otitis media purulenta Mumps	12 10 17 3 42	
Total	123	12			123	

This table shows some of the most interesting features of our problem encountered.

First, it gives the bacterial incidence of the epidemic. Of the 123 acute mastoids 81, or 66 per cent, returned positive cultures. Cultures of the middle ear have been disregarded because of the frequency of contamination, and these 81 represent cultures taken from the mastoid pus at the time of operation, and give an accurate picture of the causative organism. Considering, then, the 81 cases returning positive cultures in a group by themselves, and disregarding for the moment the 42 cases in which either no culture was made or the culture was negative, we see that the streptococcus is concerned with 59, or 73 per cent, of the 81. The staphylococcus aureus in pure culture is responsible for 13 cases, or 16 per cent, and a miscellaneous group of organisms, usually in combination, for the remaining 11 per cent.

Thirty-four of the 59 streptococcus cases were in pure culture; 5 were the hemolytic streptococcus, and 29 were proved or probably *S. viridans*. I say probably, because in the early days of the outbreak, with the hospital overwhelmed by the work entailed in its sudden expansion to meet the measles situation, the laboratory often reported the *S. viridans* cases simply as streptococcus; but they assure me that all these were *S. viridans* cultures, and the analogy with the empyemas, which were worked out later, and have proved to have a large preponderance of *S. viridans* over hemolytic infections, is very striking. I realize that this fact vitiates our statistical study to some extent, and many may be unwilling to accept it as an actual picture of our *S. viridans* infections. There is little doubt in my mind as to the morphology of this group; but in fairness the facts must be stated, that one may be able to accept or reject my conclusions, according to one's own judgment.

Of the other streptococcus cases, 17 were due to a mixed infection with staphylococcus aureus and 8 to a mixture with miscellaneous organisms—the pneumococcus, influenza bacillus, etc.

The deaths from mastoid infection numbered 12, and all occurred in the streptococcus group—7 in the *S. viridans*, 3 in the hemolytic, and 1 each in the staphylococcus and miscellaneous subgroups. These patients all died of a complicating streptococcus meningitis, proved by culture from the spinal fluids and at necropsy. Again, 8 of the 12 who died had an antecedent measles in-

fection; 1 had measles only a month prior to readmission for mumps, and developed his acute mastoiditis within a few days after entering the hospital. Of the others, two had mumps, and the twelfth entered with merely a history of otitis media purulenta. This constitutes a striking argument for the severity of the measles-streptococcus complications.

The report on this subject from Camp Taylor, Ky., states that toward the latter part of the influenza epidemic nearly every culture taken contained the hemolytic streptococcus. At that time there occurred a veritable epidemic of mastoiditis, and from the latter part of October, 1918, to February, 1919, 220 cases developed and were operated.[4]

From the Base Hospital, Camp Greene, N. C., were reported the following results of examinations of pus taken from mastoid wounds during operation:[5]

Streptococcus hemolyticus	9
Streptococcus albus	9
Streptococcus aureus	1
Unidentified Gram-negative	1
Streptococcus nonhemolyticus	1
No growth	23
Not obtained	27

Pathological Changes and Symptoms.

The pathological changes noted during operation presented a most diverse picture, the experience in this regard being similar to that noted in civilian hospitals. The predisposing disease, as well as the character of the infective organism, appeared to cause a marked difference in the character and extent of bone involvement. The destruction of bone and soft tissue was very rapid in the cases showing hemolytic streptococcus, and mastoid involvements following measles and scarlet fever as a rule were more extensive and severe than when influenza was the antecedent disease. In a study of mastoiditis submitted from the Base Hospital, Fort Riley, Kans., it was noted that:[2]

> Influenza cases develop frequent mastoid involvement without bone necrosis. On the other hand measles—mastoiditis cases—are very prone to develop bone necrosis of the fulminating type. The first necrosis occurs along the chain of cells leading from the antrum to the tip. These cells are deeply situated and have a dependent position as the patient rests in bed. The cell walls are delicate. The course of the sinus is changed at this place and causes an anatomical arrangement of these cells not conducive to easy drainage. Blocking at this point results in necrosis both in the tip and in this region.

While the symptoms noted were those associated with mastoid involvement in civil life the majority of the observers reported a marked variation in the severity of the symptoms. This was especially true with reference to the presence of pain and tenderness over the mastoid tip. These two signs, usually regarded as cardinal, could not be depended on during the presence of the "mastoid epidemic" in the Army. Some pertinent remarks on this subject, by observers in different base hospitals, are quoted.

The Base Hospital, Camp Taylor, Ky., reported as follows:[4]

> The picture of the hemolytic streptococcus mastoid, where there was no preexisting general infection, was that of a moderately sick patient. The temperature rarely exceeded 101 degrees and very often with a normal morning temperature. Pain and tenderness were exceedingly variable, ranging from practically none to the most exquisite. Where the infection was other than the hemolytic streptococcus, however, pain and tenderness was usually more pronounced. The most reliable objective symptom in diagnosis was a sagging or collapse of the posterior superior wall of the external auditory canal

The following is from the Base Hospital, Camp Bowie, Tex.: [6]

Temperature, blood count, pain, tenderness, and swelling are all of importance in diagnosis, but are unreliable. This series has demonstrated to the staff of twelve to fifteen surgeons that the one symptom which is of the utmost importance is the headache associated with otitis media and mastoiditis. For this reason all sources of headache were watched, and when no cause aside from the ear was found a radiogram was made.

From the otolaryngological service of the Base Hospital at Camp Greenleaf, Ga., comes the following report: [7]

Acute mastoiditis in a patient suffering from measles is as a rule just as free from pain as is otitis media. It is almost uncanny to believe that a patient can have a mastoid full of pus and yet insist that he is not suffering and scarcely admit any tenderness on pressure, either over his antrum or over the tip. The only sign that can be depended on are changes in the upper posterior wall of the canal. While it is the rule to find these to a greater or less degree according to the duration of the disease, we have met cases in which they were almost if not entirely lacking.

A few observers have stated definitely that the usually regarded classical sign, namely, the sagging or drooping of the posterior upper wall of the external canal, was lacking in certain of the cases observed in Army hospitals, especially in those following influenza. The majority, however, have placed great credence in this sign and report its appearance in practically all cases.

X-RAY EXAMINATIONS.

In many of the reports from Army hospitals mention is made of the assistance rendered through the X-ray examinations of suspected cases of mastoiditis. This phase of the diagnostic procedure was brought to a high degree of perfection, great advances over the previous results having been attained during the war.

Several of the chiefs of the ear, nose, and throat service at base hospitals made special mention of the assistance rendered by the X ray in the diagnosis of mastoiditis. From their reports the following extracts are taken:

Base Hospital, Fort Riley, Kans.[2]—The importance of the radiogram in the study of individual mastoid infections can not be overestimated. Hit-and-miss radiograms mean absolutely nothing. The technique must be perfected for each machine, for each step in the production of a radiogram. The clinician must study the finished plate with the roentgenologist. One plate is not always sufficient. Both mastoids must be shown on one plate for means of comparison. When a new make of plates is used the technique must be revised. One person should take all the exposures of a single mastoid case. If these rules are observed, the opening statement will prove true.

One of the most important observations has been the use one may get from the X ray in mastoid work. At first this was overlooked. In a series of roentgenograms, it was demonstrated that there is a marked symmetry of the two sides; i. e., the cellular structure of the right mastoid is almost identical with the left in each case. Operations demonstrated the truth of this statement. This is of great advantage in operating, as it gives the operator a clue as to the amount of bone to remove.

Base Hospital, Camp Taylor, Ky.[4]—The X ray was a valuable adjunct in diagnosis and was used in practically all cases. Some very beautiful evidences of bone destruction were shown but in many of the hemolytic streptococcus infections it was extremely hazardous to wait for X-ray findings, on account of the rapid destruction of the bone.

Base Hospital, Camp Merritt, N. J.[8]—In doubtful cases the X ray proved a very valuable adjunct. The X-ray picture was also helpful as a guide to the operation, the extent of the process and size of the mastoid and position of the lateral sinus.

OPERATION.

A study of the list of operations performed in different base hospitals, as recorded in a previous chapter, shows that the number of mastoidectomies

performed varied widely. This was because certain camps had a higher incidence of the acute infectious diseases which were the underlying causes of mastoiditis, and the fact that the virulence of the responsible organism, as well as its affinity for the auditory organs, differed materially throughout the country. In addition, the personal equation of the chief of the service at each hospital, with respect to the advisability of early operation and as to whether operation was required, must have been an important factor in determining the number performed in the given hospital.

From a consideration of all the reports received it is evident that the general opinion was that early and complete operation offered the greatest advantage to the patient. It may be of interest to consider the expressions of opinions on this subject of the chiefs of the otolaryngological services at the following hospitals:

General Hospital No. 24, Park View, Pa.[9]—Upon the recognition of changes in the auditory canal walls, operation is indicated. In rare cases where these changes are absent, with excessive discharge or destruction of the drum membrane continuing for a number of days, it has been our rule to operate. Any definite day of disease for operation is out of the question. We have never operated too early even if it has only been the fourth, fifth, or sixth day. Often we should have operated earlier. Operation is wont to disclose extensive changes in the mastoid cells. If the operation has been performed early enough, the progress to recovery while usually slow is uneventful. If operation has been delayed, it is common to meet with epidural abscess, sinus thrombosis, brain abscess, or meningitis.

Base Hospital, Camp Greene, N. C.[5]—The object in operating was to preserve the hearing and to reduce the time in hospital to the minimum. We always considered the classical symptoms: (1) Drooping or sinking of the posterior superior wall of the auditory canal just external to the tympanic membrane; (2) copious discharge, not lessening after seven or eight days' treatment; (3) pain behind the ear or at mastoid tip; (4) swelling over the soft parts; (5) general indisposition, frequently without pain; (6) blood picture; (7) X-ray picture; (8) meningeal symptoms; (9) sudden cessation of discharge with continuance of pain; (10) temperature.

Always considering the above 10 points, we have found that if the discharge was not decidedly decreased at the end of seven or eight days mastoidectomy was indicated.

Base Hospital, Fort Riley, Kans.[2]—To class all mastoiditis cases in one group and to operate only when the clinical symptoms are pronounced is the tendency of most surgeons. The result of this procedure is uncertain. To advocate early operation on otitis media cases presenting mastoid tenderness is even less advisable. The ideal method would be to strike a happy medium—an impossible procedure. If one awaits the appearance of clinical symptoms of mastoiditis warranting operation, many cases will be so far advanced that destruction of bone, unsightly scars, and even death may result. If one operates too early, before bone necrosis occurs and resistance of the body to infection is present, one subjects the patient to unnecessary risk, the possibility of secondary operation because of bone infection and because of rapid absorption following operation. There can be no set rule, for cases require both early and late operation depending upon circumstances connected with the individual case.

Base Hospital, Camp Taylor, Ky.[4]—Early operation with complete exenteration of the mastoid area gave a lower mortality and better after results. The average time of hospitalization following operation was six weeks.[3]

Base Hospital, Camp Dix, N. J.[10]—I am persuaded that all running ears that persist for three weeks should have the mastoid operation. During the service this opinion became a conviction after opening two mastoids without symptoms and finding extra dural abscesses which had given no symptoms excepting the discharge.

Type of Operation.

The experience of all operators was that in the type of mastoiditis seen in the military service during the war no classical operation could be followed.

Each case constituted a problem in itself and had to be worked out along individual lines. The important desideratum was the complete removal of all diseased tissue and the establishment of proper drainage, if indicated. As has been previously stated, the extent of bony destruction seemed dependent, in many instances, on the character of the invading organism, the hemolytic streptococcus being the worst offender.

The following quotations from the reports of the chiefs of the otolaryngological services at a few of the base hospitals set forth the views of the operators regarding the nature of the operation, based on their individual experiences:

Base Hospital, Camp Greene, N. C.[5]—When we operated we endeavored to remove all cancellated tissue, diseased or not, always securing free drainage from the middle ear through the aditus ad antrum, packing lightly with gauze drainage, closing the upper two-thirds of the wound with two or three silkworm gut sutures, being careful to include the periosteum. If not soiled, the dressings are not removed for 48 hours. The packing is removed two or three inches a day and by the time that it is all removed, five or six days, it is not repacked. No irrigation is used.

Base Hospital, Camp Lewis, Wash.[11]—Upon operation thorough exenteration of the mastoid cells was attempted. It is fair to say that infected areas were not infrequently overlooked in spite of the extensive operation. Dura and lateral sinus were often exposed and perisinus abscesses evacuated. According to the choice of the operator, the wound was more or less closed but never completely. Owing to extensive destruction, the convalescence was prolonged. Secondary suturing became necessary in several instances, the results of such procedure being uniformly good.

Much patience was exercised by the officers in charge and every attempt was made to hasten recovery. In spite of this, however, healing was not complete for many months and in certain cases a radical mastoid seemed inevitable. Because of a ruling discouraging radical mastoid operations in field hospitals, cases were permitted to remain under conservative treatment and in several severe cases after request had been made to transfer them to general hospital for radical operation, healing resulted before the order for transfer came through.

Base Hospital, Fort Riley, Kans.[2]—Any operation which has for its object the complete exenteration of the mastoid cells, drainage of the antrum, and least possible trauma, is sufficient for the relief of mastoiditis. This means that sufficient bone must be removed to obtain access to all necrotic areas, even though it requires exposure of the sinus or dura.

Base Hospital, Camp Pike, Ark.[12]—The operation we have found necessary to perform in these cases of streptococcic (hemolytic) osteomyelitis is far from being a simple mastoidectomy, neither has it the limits of the so-called radical mastoidectomy. I would term the procedure as carried out here the ultra radical mastoidectomy, for the reason that there are no exact limitations to the extent of bone removal. We have had to go back into the occipital, and above into the squama and posterior and inferior angle of the parietal, and penetrate the petrosa to the bony capsule of the labyrinth and the facial canal. Sinus and dural exposures are made necessary, in nearly every case, to the bulbous portion of the sinus. The diseased bone uncovered demands these extraordinary bone removals. The disease is not limited to the mastoid and zygomatic cellular systems; it extends into the diploic structures. Even after such radical operative procedure the disease has in some cases continued progressive and has been found when uncovered at autopsy to extend to the extreme limits of the petrosa. Resistance in the individual seems to be the factor which determines recovery.

Base Hospital, Camp Merritt, N. J.[8]—Primary suture was tried in five cases. Three were successful, two not. One soldier returned within 48 hours to the hospital, after having been put on guard duty in the rain, with a fresh infection of the middle ear and a breaking down of the scar. It was not successful in the streptococcic infections.

Comparatively few radical mastoidectomies were performed. The majority of the soldiers with chronic otitis media and mastoiditis had this condition when they entered the Army; they were discharged for physical disability.

Anesthesia.

The large number of cases of pneumonia and empyema which complicated the acute infectious diseases often contraindicated the use of general anesthetics, especially ether, when an accompanying mastoid involvement required operation. At times nitrous oxide gas was successfully used, but the excellent results attending local anesthesia made it the method of choice with many operators. An idea of the extent to which local anesthesia was used, and of the enthusiasm of various operators regarding it, can best be given by quoting from the reports of the otolaryngological services of some base hospitals:

Base Hospital, Camp Bowie, Tex.[13]—A noteworthy feature of the mastoid surgery was the performance of a number of mastoidectomies under local anesthesia. In 2 cases apothesine was used and in 19 cases novocaine. The first case operated on by this method of anesthesia was one of pneumonia, whose crisis occurred April 11, 1918. Three days later he had imperative indications for a mastoidectomy and to avoid the pulmonary complications almost certain to follow a general anesthetic, novocaine was used, with eminently satisfactory results.

From this experience we were led to operate a number of other patients with similar history by the same anesthesia, and another group with no antecedent lung condition, in which the choice of an anesthetic was optional. It was demonstrated beyond a doubt that local anesthesia of the mastoid was feasible and much to be preferred to general anesthesia for mastoidectomy in selected cases.

Base Hospital, Camp MacArthur, Tex.[14]—Since October 6, 1917, 24 simple mastoidectomies have been performed. Of these three were under local anesthesia on account of complications which precluded ether. The anesthetic used was cocaine one-fourth of 1 per cent, and adrenalin 1/10000, and was infiltrated as in Schleich's method. The undersigned has had no experience heretofore with local anesthesia in mastoidectomy but is favorably impressed with the method.

Base Hospital, Camp Dix, N. J.[10]—Three acute mastoids were performed entirely under local anesthesia, in cases suffering from pneumonia. No pain whatever was experienced. The technique consisted of infiltration of first, the skin; second, the periosteum; third, the membranous canal.

No pulling on soft tissues being allowed and all bone work being done by electric drills and rongeurs, if all shock by chiseling, etc., is avoided, the whole mastoid operation can be conducted almost without the knowledge of the patient.

After-treatment.

The after-treatment of mastoidectomies was conducted along the lines regarded as suitable by individual operators. Naturally there was a wide divergence of views as to the best methods to employ. Carrel-Dakin solution was extensively used, as was also a paste made with dichloramine–T, and the reports received from base and general hospitals speak highly of the merits of these drugs for use in this connection. If the Carrel-Dakin solution was used too constantly an irritation of the tympanic cavity and tympanum was caused which had to be guarded against.

Complications.

The two most serious complications following mastoidectomy were meningitis and brain abscess. It was the opinion of several observers that the meningitis was not always a direct sequela of the mastoid involvement but that in some cases the meninges were infected directly through the blood stream and entirely independent of the local mastoid infection. This impression was confirmed by autopsy in several instances.

DEAFNESS.

Between April 1, 1917, and December 31, 1919, 399 soldiers were discharged on certificate of disability by reason of defective hearing (cause not stated). The primary cause of the deafness in 365 of these cases was regarded as having originated in the United States. In addition to those just mentioned 5,492 soldiers were discharged by reason of otitis media, 125 for mastoiditis, and 180 for other diseases of the ear.[1] In a large proportion of these cases deafness undoubtedly existed and was a prime factor in the man's being regarded as unfitted for military service.

The classes of deafness which have been especially mentioned in the reports of the various otolaryngological services included:

Deafness following chronic otitis media and chronic mastoiditis.—These two diseases were probably responsible for a large proportion of the deafness which arose in the Army. Deafness of this character differed in no way from that which the aurist was accustomed to see in civil life.

Concussion deafness.—This was the distinctive military type of deafness. It was usually the product of actual warfare and its appearance was largely confined to our troops in France, although the following extract from a report from the Base Hospital, Fort Sill, Okla., indicates that the condition did arise in this country: [15]

Artillery deafness has been rather frequently observed at this post. It usually occurs in the case of gunners who have been firing for many weeks. The chief complaints are partial deafness, usually more marked in one ear, and tinnitus. Vertigo is usually absent. Objectively no gross lesions are observable. The disease seems to be of cochlear origin and the result of repeated concussions, especially when the ears have been protected. Treatment is of little benefit, and a transfer to some other branch of the service is usually advocated in order not to add insult to an injured organ.

A number of cases of concussion deafness in men returned from overseas were seen at General Hospital No. 11, Cape May, N. J., and are thus discussed by the chief of the otolaryngological service at that hospital: [16]

There were 30 cases of bilateral deafness, due to concussion from exploding shells. In some of these cases the drum membranes were ruptured by the concussion, but in many of them there was at least no evidence and no history of ruptured membranes. The few cases which were not rendered unconscious by the concussion described it as a tremendous explosion, with the sensation of being struck by some flying object. In these cases the labyrinthine reactions were all diminished, but not absolutely destroyed, and the deafness which was complete immediately after the concussion almost invariably improved somewhat, so that men could hear a loud voice from 1 to 2 feet and were able to hear their own voice and modulate it, and to avoid the monotone which is present in congenital deafness.

Hysterical deafness.—This form also was of much more frequent occurrence in the American Expeditionary Forces than at home, and most of the cases seen in the base and general hospitals in this country were returned soldiers. The chief factors in the treatment of this form of deafness were suggestion and persuasion. Local treatment was of little benefit. In connection with this condition the following extract is from the otolaryngological report from General Hospital No. 11, Cape May, N. J.: [16]

We had only two cases of hysterical deafness, both of which recovered. In each case we decided that the deafness was hysterical by talking to the patient in a low voice while we were conducting the rotation tests. Rather naturally their attention was so diverted by the turning test that they forgot about their deafness and the hysterical element was evident.

Deafness following gunshot wound or other injury of skull.—This form was frequently unilateral in character, corresponding to the injured side of the head. The majority of these cases originated in France as the result of battle injuries, but a few were noted in this country following fractures of the base from falls or blows on the head.

Deafness following the injection of salvarsan.—Only a few cases of this character were reported and these were similar in every respect to the cases seen in civil life.

LIP READING.

Realizing that many cases of marked deafness must develop in so large an army, the otolaryngological section, the Division of Head Surgery of the Surgeon General's Office, prepared plans by which lip reading on an extensive scale might be taught these unfortunates. A school for this purpose was established at General Hospital No. 11, Cape May, N. J., and all soldiers requiring instruction were transferred to that hospital. Experienced instructors were engaged and every effort was made to render the course effective. The success attained is shown by the following report of the chief of the otolaryngological service:[16]

Eleven of the most capable lip-reading teachers that could be found in this country were secured for this work. These women, like most of the men who went into the service from civil life, made decided sacrifices to enter the service, and their skill and loyal work deserves the highest commendation. Each man received individual instruction, beginning with a period of 45 minutes daily, and then increasing the periods so that each man met his teacher two or three times a day. Under this system of concentrated teaching the majority of these men made wonderful progress, and in from six to eight weeks many of them became very expert lip readers, so that in conversing with them one scarcely realized that they were deaf. A few of them became so expert that they could read the lips in the moonlight. These deaf patients were invariably very much depressed when they entered the hospital, but as they became able to read the lips their whole attitude changed. They would begin to associate with their companions, and to join in the games, and they realized that their deafness was much less of a handicap than they at first considered it to be. Instead of being dejected and more or less morose they became practically normal individuals, and it was a constant source of pleasure to see these men develop.

GUNSHOT WOUNDS.

Injuries of this character were seen, for the greater part, in wounded soldiers invalided home from the American Expeditionary Forces, the majority of whom were admitted to General Hospital No. 11, Cape May, N. J., for treatment. In the report from this hospital the following notation is made:[16]

In practically all of the cases which were wounded in the mastoid region the shell fragments penetrated the mastoid, destroying more or less completely the external auditory canal and injuring the facial nerve. All of these cases were deaf in the injured ear, due either to partial destruction of the cochlea, or to concussion. Most of these cases of facial paralysis recovered almost completely when the foreign body and the splinters of fractured bone were removed, thus relieving the compression and irritation of the facial nerve. In all cases of facial paralysis the paralysis was treated with electricity and message, and in our judgment this treatment hastened the recovery. In all of these cases we did what amounted to a radical mastoid operation, to enable us to remove the foreign body and reestablish the auditory canal.

We had two cases of gunshot wound of the auricle only, with synechia causing occlusion of the auditory canal. These conditions were rectified by plastic operations on the auricle and the canal. In both of these cases the hearing in the injured ear was nearly normal. Most of the cases of injury of the ear and mastoid region were due to primary wounds in this region. We had, however, a few cases in which a machine gun bullet entered some other part of the head and went out through the mastoid.

EAR PROTECTORS.

Before closing the chapter on diseases of the ears, one other subject must be considered, although no official action concerning it was taken. This is the question of ear protection during warfare involving the use of high explosives. The officer in charge of the section of defects of hearing and speech of the Reconstruction Division in the Office of the Surgeon General realized, during the early days of the war, the possibility of many cases of concussion deafness developing and also believed that by the enforced use of properly made and fitted ear protectors the occurrence of this form of deafness could be reduced to a minimum. A thorough study of this subject was made and the advantages of various types of protectors were tested but no definite action looking to the adoption and supply of these articles was taken.[17]

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CHAPTER VI.

OTOLARYNGOLOGICAL COMPLICATIONS OF INFLUENZA.

With the onset of the epidemic of influenza which overwhelmed the entire country during the autumn season of 1918, an apprehension naturally arose in the minds of the otolaryngologists that severe complications and sequelæ involving the nose and ear must be expected to follow. Fortunately, the complications of this nature which attended the epidemic were relatively less than were expected, but the great total of influenza cases provided a large number of complications which fell to the care of the otolaryngological service.

The sudden appearance of this disease with the large number of men stricken, necessitated, in the great majority of camps, a rapid expansion of hospital facilities beyond their normal bounds, and the detail of all available medical officers to assist the medical service. In this way the otolaryngological staffs of hospitals were reduced in strength and for those remaining therein the number of wards to be visited was increased. For these reasons exact records could not be kept in many of the hospitals, consequently accurate statistics as to complications of influenza are not available.

Prompt measures were instituted by the chiefs of service in all hospitals to provide for immediate examination of all influenza patients who presented any signs of otolaryngological complications, especially of ear involvement. Characteristic of the policies introduced in this regard were those put in force in the base hospitals at Camp Hancock and Camp Sherman. The following extract is from a report from Camp Hancock:[1]

The main concern of the department was the ear, especially in its suppurative and mastoid aspects. The present chief of service at Camp Hancock was determined from the first to leave unattended no detail which would promote the healing of acutely affected ears and prevent mastoid complications. In this he was ably and untiringly supported by the members of his staff, by the chief of the medical service, and by the ward surgeons, by the former in ordering and carrying out the treatment decided upon, and by the others in cooperating in every way in carrying out the plans laid down.

In order that all such complications should receive prompt attention, request was made at an officers' meeting that all cases of ear pain be reported at once to the department of otolaryngology. This was to be in force both during the day and night. This request soon was found to be insufficiently broad, because in the first days of the epidemic it was noted that some middle ear cavities were found to be filled with pus, with the patient complaining, not of pain, but only of deafness and a sense of fullness in the ear. As a result of this observation it was requested that any patient complaining of any ear symptom whatsoever, even if only a sense of fullness, be immediately reported to the otolaryngological department. In order that no calls should go unanswered, an orderly constantly was on duty in the head section building, one orderly sleeping in the building near the telephone. It was hoped in this manner to secure prompt 24-hour service, and such in fact proved to be the outcome.

By this plan, nearly, if not quite, every patient who presented ear symptoms was seen by a specialist within half an hour of the time notification of his condition was received by the department.

In carrying out the details of visiting the cases, the hospital was divided into three equal parts, and to each part was assigned one junior member of the staff. These men started in at 8 o'clock in the morning and made rounds of the portions of the hospital assigned to them. At each ward or tent group the surgeon would see the cases which he knew required attention and

would inquire as to whether or not there were any others. At 10.30 a. m. each man would telephone the clinic to find out if any emergency calls had been sent in from the portion of the hospital under his care. The night calls were answered by the officer on emergency duty, and when there was more work than he could handle, a second and sometimes a third member of the department was called upon.

The chief of the department remained throughout the day in the head section building, receiving calls and distributing them, and seeing, with the ward visiting surgeons, those cases on which the latter desired the opinion of the chief.

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A second handicap was the impossibility, on account of relative shortage of nurses and orderlies, of carrying out in detail the routine ear treatment which was in force in the hospital.

Otolaryngologists agree that in all cases of acute tubotympanic disease treatment of the nose and nasopharynx is advisable, not to say imperative. Under the conditions in which this epidemic was handled, it was utterly impossible to administer such treatment. The nursing and orderly staffs were driven to the utmost in order to carry out the fundamental necessities of general treatment, and neither personnel nor appliances were available for nasal treatment. Almost to a man the cases of ear involvement went through the attack with no treatment except to the ear, and so successful was the outcome that one is tempted to question the vital necessity for nasal and nasopharyngeal treatment as a routine measure in acute middle-ear disease.

At Camp Sherman, Ohio, what was called an extra-mural service had previously been instituted and was continued on a modified scale during the continuance of the epidemic, with excellent results. One or more officers were equipped with a complete treatment outfit and every day visited each ward outside of the regular ear, nose, and throat wards, and examined every case that had the slightest indication of having any ear, nose, or throat involvement. The necessary treatment of bed patients was conducted in the wards, and where mastoiditis developed the chief of the service was notified and personally examined the patient.[2]

The frequency of ear, nose, and throat complications of influenza varied markedly throughout the different camps. The reports from all hospitals, however, agree that these complications were generally of a mild nature, much less severe than might have been expected considering the virulent character of the epidemic.

Coryza and bronchitis were among the first symptoms of influenza noted in a large percentage of the cases. These conditions were usually of a mild character and required little special treatment. In fact, due to the great rush of work in caring for the more severe cases, it was impossible to provide local treatment for these conditions. In a report from the Base Hospital, Camp Fremont, Calif., the following statement is made:[3]

The coryza, which in so many cases was the first respiratory symptom to appear, was mild in character and subsided rapidly. The same may be said of throat symptoms, when present. In most patients the infection seemed to jump from the nose to the bronchi, without affecting the pharynx. Indeed, the most striking point in this epidemic from the standpoint of otolaryngology is that the infective organism or organisms, while showing a definite predilection for the bronchial tree, passed lightly over the deeper nasal tissues, the middle ear, and the throat. The bronchitis was often severe and persistent.

The following was reported from the Base Hospital, Fort Sill, Okla.:[4]

From the records covering more than 100 cases it was found that 44.5 per cent complained of sore throat. The throat condition was characterized by hyperemia more or less marked, often limited to the pharynx, sometimes involving only the pillars of the fauces. The picture was that of a simple acute pharyngitis, at times that of a pharyngitis lateralis. The tonsils were not especially involved.

Epistaxis was comparatively frequent in all hospitals. The bleeding, while seldom of a serious nature, was often most persistent, and in some instances packing of the nose and nasopharynx was necessary. The hemorrhage usually came from the anterior portion of the septum. In many cases the epistaxis was believed to have been caused or aggravated by the irritation of solutions used in douching or spraying the nasal passages or by traumatism produced by unskillful use of atomizers.

Sinusitus was not frequently diagnosed clinically but probably existed more often than was recorded. The chief of the section of surgery of the head, Base Hospital, Camp Dix, N. J., states in a report:[5]

As the result of witnessing a number of post-mortems on cases that had died from pneumonia, I was impressed with the frequency of the involvement of the accessory sinuses of the nose; however, involvement of the sphenoidal sinuses alone was not noticed, many of the post-mortems showing involvement of the ethmoidal sinuses without involvement of the sphenoid.

In a series of 15 autopsies of patients dying of pneumonia complicating influenza, performed at Camp Sevier, S. C.,[6] the accessory sinuses were found to contain pus in 8 instances, while in 7 they were normal. In the 8 cases in which the sinuses were affected the sphenoids were diseased in all, the ethmoids in 5, the frontals in 4, and the maxillary sinuses in 2 cases.

In a series of 17 autopsies conducted at the Walter Reed General Hospital[7] on subjects dying from pneumonia complicating influenza, the nasal sinuses were uncovered, and in each instance at least one of them was involved. The sphenoids were most frequently affected, followed in order by the ethmoids, frontal and maxillary. To serve as a control of these findings the sinuses of two other patients who died during this period from other causes were examined and in each instance were negative. The predominating organisms found in the series of 17 cases were the staphylococcus and pneumococcus.

At the Base Hospital, Fort Sill, Okla.,[4] only 1 per cent of all influenza patients had proven sinus involvement. The chief of service, believing that the true percentage might be much greater, transilluminated 143 unselected cases at night and found that 17, or 11.8 per cent, gave positive indication of involvement. Ten of these seventeen cases were punctured and irrigated and in eight of them the diagnoses were confirmed.

The experience at the Base Hospital, Camp Bowie, Tex., was contrary to that at many of the camps, as shown by the following report:[8]

Many cases of accessory sinusitis developed, the antrum being most frequently involved and generally requiring puncture and repeated washings and aerations for a cure. Such frontal and ethmoidal sinusitis as occurred was relieved by adrenalin tampons with a few exceptions, where a middle turbinectomy was required for relief.

A report from Camp Taylor, Ky., states:[9]

Accessory sinus involvement was frequent and very severe. Where there was no preexisting inflammation the sinus was filled with a thick, cloudy mucus containing the influenza bacillus and occasionally the hemolytic streptococcus. The majority of these cases responded readily to drainage and a few irrigations with normal salt solution. Where the infection was complicated by some of the pyogenic organisms or where there was a chronic sinusitis existing the case was more prolonged and frequently required more radical surgery to effect a cure.

In all instances cases which were recognized responded to the ordinary means of treatment and cleared up in a short time. No record has been found of any resultant chronic cases.

In all hospitals laryngitis was noted as a complication of influenza, though the ratio of cases affected varied greatly. At Camp Sevier, S. C., laryngitis was a prominent complication in 18 cases. Hoarseness was present in varying degree up to almost complete aphonia, and was characteristically persistent for weeks after its onset. At Camp MacArthur, Tex., it was noted that in patients who suffered a severe cough, in many instances there was found to be marked pharyngitis with edema of the false vocal cords but very slight inflammation of the true cords. In some instances the true cords were highly inflamed and caused the patient some uneasiness on account of inability to speak above a whisper for a few days, but this was overcome in only a few days, with no after results.

General Hospital No. 14, Fort Oglethorpe, Ga., reported:[10]

Occasionally there was laryngeal involvement, a diffuse inflammatory process involving the false cords and epiglottis, with varying degrees of swelling and redness of the true cords, and consequent limitation of motion. In some cases it was quite impossible to see the cords. Two cases showed hemorrhagic vesicles of the true cord. These were unilateral and situated about the junction of the anterior and middle third. Later these ruptured and gave the appearance of superficial ulcerations about 3 mm. in diameter. These healed with treatment in about 10 to 12 days.

A very interesting discussion of the laryngeal complications found in the report from the Base Hospital, Camp Hancock, Ga., follows:[1]

Larynx.—Laryngitis was present in quite a few cases, and the manifestations in the larynx were of three different types: (1) Diffuse catarrhal laryngitis, with the usual appearance found in this condition; (2) ulcerative laryngitis, with small, narrow, superficial ulcers running lengthwise of one or both cords; (3) what might be called asthenic laryngitis.

A section of ulcerated cord from a case of type (2) was submitted to the pathologist, who reported on the specimen as follows: "Section shows mucosa with an irregular loss of substance, with submucosa exposed, which with muscle tissues still deeper is infiltrated with polynuclear leucocytes. Diagnosis: Acute inflammation of vocal cords with ulceration."

The last form deserves a more detailed description. It was found almost entirely in a group of cases which came from among the soldiers who had been in Camp Hancock for some time. It was characterized by a normal or slightly reddened mucosa, absence of ulcerative lesions and mainly by a marked weakness of the laryngeal musculature. An attempt at phonation would result in a feeble effort to approximate the vocal cords and an immediate discouraged return of the cords to the respiratory position. A similar condition of the palatal and pharyngeal and probably of the esophageal musculature usually was found to be associated with it. The muscular efficiency of the entire throat was very low, and it was tested out in one patient by having him endeavor to swallow a large mouthful of water. The effort at deglutition immediately was followed by a gush of water from his nose and by cyanosis. It was evident that the muscles neither of his soft palate nor of his larynx had the strength to close off the entrances to the cavities which they guard. In a short while he was able by a few weak coughs to clear his larynx and trachea, but for the moment it looked as if he was in imminent danger of suffocation from the water which he was unable to expel from it.

The actual cause of this condition could not be determined. Possibly it was a toxic myositis, possibly just a part of the general asthenia, possibly it was due to a toxic poisoning of the centers in the medulla, really constituting an acute form of bulbar paralysis.

The complication of influenza which was of most importance to the otolaryngologist and which, from the number of cases that had followed previous epidemics of respiratory diseases was expected to be most serious, was otitis media, with, in many cases, the attendant mastoid involvement. Fortunately, the fears in regard to this disease were not realized and the cases in which it occurred were relatively few. The organism or organisms responsible for the

influenza did not seem to exercise any selective action for the ear or mastoid. The number of cases in which this complication appeared was, in fact, as stated, proportionately much less than had followed the measles epidemic of the previous year. Otitis media, when it did occur, was usually of a mild character, and the proportion of mastoid involvements was not large nor, in most hospitals, were they of a serious nature.

The experience of most camps was very similar in this respect. Careful examination of the ears was made by otolaryngologists as soon as any sign of ear trouble was noticed by a patient, and to this fact is probably due, in a large measure, the small number of mastoid extensions. As soon as any indication of existing middle-ear disease was detected myringotomy was done and careful treatment instituted.

In a report on the activities of the otolaryngological service at General Hospital No. 14, Fort Oglethorpe, Ga., the chief of the service discusses at some length the aural complications of the influenza epidemic at that station. That portion of his report relating to otitis media and mastoiditis is given in full, as it is in general characteristic of these conditions as they existed throughout the Army.[10]

The recent epidemic of influenza has shown certain very interesting features from an otological standpoint. Otitis media was not a very frequent complication but those cases in which it did develop were of perfectly characteristic type and showed the clinical picture we had come to consider as influenzal. There were, however, some unique features which are well worth considering.

Out of a series of 6,870 cases of influenza occurring at the United States Army General Hospital No. 14, there were only 120 cases of acute suppurative otitis media. There were 1,600 cases of pneumonia in this series and 66 of the cases of otitis media occurred among these. Of the 120 cases, 17 were bilateral, 16 of these occurring in the pneumonias; 21 cases developed mastoiditis, 2 of these being bilateral; 1 case developed acute suppurative otitic meningitis and died. The percentage of influenza occurring in cases uncomplicated by pneumonia was 1.02. Of the series of 6,870 cases, there were 6 cases of acute frontal sinusitis and 3 of ethmoiditis. No maxillary sinusitis was noted. There were 16 cases of acute laryngitis, 16 cases of acute follicular tonsillitis, and one of peritonsillar abscess. There was a small number of acute catarrhal otitis media reported. For acute respiratory diseases this seemed to be a small percentage of aural complications. It is safe to say that none of these were overlooked, as these cases were under constant observation, and there are always competent otologists available to examine suspected cases. Each case was seen early and immediate treatment instituted. However, there are certain grounds for error in these figures, as on the day they were compiled there were 173 cases of influenza still in the hospital and potential subjects of aural complications. We must conclude from these figures that the percentage of otitis media occurring in influenza is comparatively small, the greater proportion occurring in those cases complicated by pneumonia.

However, those cases of otitis media which did develop as a result of influenza showed certain very interesting if not unique features. In practically every case the type ran true to form. This seemed to show distinct pathology, such that it was necessary for us to revise our old symptomatology. This pathology seems to be best described as an acute hyperplasia, or hyperplastic edema of the mucous membrane of the middle ear. The onset was quite sudden, generally occurring in from the first to third day of the disease. A certain number of cases of otitis media showed clinical pictures identical with those in the influenza cases but had absolutely no other manifestations of the disease. They reported to the hospital showing what we came to regard as influenzal otitis media and were treated as such, but of course were never diagnosed as influenza.

The first symptom was intense pain in the infected ear together with, or sometimes preceded by, a feeling of fullness. The headache and malaise occurring in these cases must be attributed to the general effect of the influenza, and the temperature, which ran from 101 to 104, must be considered in the same way. The otitis media of this type, but occurring in otherwise noninfluenzal cases, ran a normal temperature. Otoscopic examination of the cases within two or three hours

after the onset of pain would show distinctive changes in the membrana tympani, always of a vesicular type. In almost every case there was marked redness and some bulging of Shrapnell's membrane. There was injection along the handle of the malleus. The light reflex was usually present and often the anterior portion of the membrana tympani appeared quite normal. The superior posterior quadrant showed the greatest change. There was frequently a large hemorrhagic bleb bulging outward even for two or three millimeters. The short process often could be seen. This was in the typical early cases seen within two or three hours after the onset.

The cases seen later showed more swelling, especially of the superior posterior portion, diffuse reddening of the membrana tympani and loss of all normal landmarks. The distinctive feature was a bleb formation. Often there were two or three of these, always superior, either anteriorly or posteriorly, and often directed marginward beyond the annulus end to the wall of the external auditory meatus. These were of considerable size, often being five or six millimeters in diameter, obscuring a good view of the membrana tympani. The eccentric layer of the squamous cell epithelium, making up the stratum cutaneum of the membrana tympani, readily explains this traveling of the blebs laterally to the canal wall. There was no tenderness over the mastoid process at this stage. Incision of the blebs evacuated a small amount of bloody serum. In the older cases this could be expressed from the vesicles only with some effort, as if some clotting or organization was taking place. These blebs were true vesicles beneath the stratum cutaneum of the membrana tympani. After evacuation of these the drum appeared red and swollen, with the marked involvement of Shrapnell's membrane, previously mentioned, the degree or extent depending upon the time involved. Incision of the membrana tympani in the earlier cases gave relief to increased pressure within the middle ear, followed by considerable bleeding. Later this became a profuse, serosanguineous discharge. In the cases seen at a more advanced stage incision evacuated this serosanguineous discharge immediately.

The pain generally subsided about two hours after the incision of the membrana tympani. The serosanguineous discharge continued rather profusely for several days, then gradually changed in character to a thin purulent discharge, which later became of thicker consistency, apparently due to secondary infection.

The nose and throat examination of these cases showed considerable congestion of the mucous membrane throughout, with more or less purulent secretion in the epipharynx and a diffuse acute pharyngitis.

Presumably we had a very acute, suppurative otitis media, rapid in onset, of nasopharyngeal origin. Almost from the onset a marked epitympanic involvement became noted. An outstanding feature was the early obliteration of the superior angle of the external auditory canal and membrana tympani, sometimes seen on the second day of the disease. With this there was increased swelling of the membrana tympani itself, and often further bleb or vesicle formation, though after incision of the drum no new extra-marginal blebs were seen. With the obliteration of the superior angle Shrapnell's membrane became pushed downward. The line of incision frequently was depressed inward by the increased thickness or swelling of the membrana tympani. Often a bleb or vesicle would protrude out through the incision.

One case showed a large bleb in the upper limit of a right-angle incision of the membrana tympani. The process was apparently a subsiding one and this was not disturbed. The next day this incision was smaller and the bleb had a balloonlike appearance. This became a pedunculated sac of considerable length, but narrow pedicle, which gradually became choked off altogether, with a final closure of the opening. This was removed and gave a microscopic appearance of mucous membrane.

Generally, there was what seemed to be a hyperplasia of the mucous membrane of the middle ear. Sometimes this protruding through the opening in the membrana tympani would give the appearance of granulation tissue, except that it did not bleed so easily. In one case this hyperplastic tissue coming through the membrana tympani high up, dissected away the superior angle of the drum, giving the appearance of a polypoid mass. This was freely movable without discomfort to the patient and did not bleed. Upon subsiding, this gave a rough bubbly appearance to the membrana tympani. The serous discharge showed considerable tendency to coagulate, especially over the incision, and it was frequently necessary to remove this to allow drainage. Frequently secondary incisions were required. Mastoid tenderness or edema was not evidenced at this stage. In certain of the cases the process now began to subside and go on to an uneventful convalescence. The discharge ceased and the middle ear began to resolve with reappearance

of the normal landmarks and the obliteration of the incision. The last remaining sign of the infection was the irregular thickening and swelling of the superior posterior quadrant of the membrana tympani, giving it an uneven, bubbly appearance.

In other cases, in from 10 to 12 days from the onset, the whole superior canal wall would become flattened. This was so marked as to be an absolute dropping, and occurred in practically every case, with occasional pushing forward of the posterior canal wall at its innermost portion. By this time the discharge had changed in character to thin purulent. Thus, the typical clinical picture would be a suppurative otitis media of 10 to 12 days' duration, showing a thin purulent discharge and absolutely flat superior canal wall, the membrana tympani red and swollen, especially in the superior portion, with or without bleb formation, and all normal landmarks obliterated. Usually there was no mastoid tenderness or edema.

From this point the cases varied somewhat. In many there was a lessening of the discharge which, however, persisted in smaller degree for a week or 10 days. The middle ear gradually resolved and landmarks appeared. About the last sign to disappear was the flattened superior canal wall. Even after the membrana tympani had regained almost normal appearance and color, a certain percentage ran along for several days without showing much change, and then, with some increase in the discharge, there was a distinct thickening of the mastoid periosteum with occasional slight tenderness and edema over the tip. Sometimes these showed a slight rise in temperature and complained of pain at night. They were diagnosed as mastoiditis and operation confirmed it. Some cases, notably in the pneumonias, showed a thick, creamy, purulent discharge, increased in amount, and a definite boggy appearance of the membrana tympani. There was no mastoid tenderness but always a thickening of the periosteum. These also came to operation as mastoiditis.

Of the 21 cases which came to mastoid operation, 1 showed a normal mastoid, 2 simply a congestion of the mucous membrane of the cells, while the rest were pretty much of a characteristic type. They showed a hemorrhagic cortex which, upon removal, revealed more or less free pus. The bone was not broken down. In all cases the cell structure was preserved, though somewhat softened. Often there were granulations in the cells. Frequently there was considerable involvement of the zygomatic cells. In some cases the bone over the lateral sinus was rather soft but not broken down. In 2 cases there was erosion of the tegmen antri. For the most part, these cases had uneventful convalescence, the middle ear becoming dry within two or three days and the wound healing nicely. One of the cases mentioned above, with erosion of the tegmen, developed a plastic leptomeningitis and died. This was complicated by a severe pneumonic process involving both lungs.

A noteworthy feature was the flattened superior canal wall, seen first as an obliteration of the inner superior angle of the membrana tympani and canal. Ballenger considers this a sign of marked suppuration in the border cells of the mastoid and usually a sign for operative interference. Our experience did not bear this out. One case which showed absolute flattening and no signs of external otitis revealed at operation a perfectly normal mastoid. Other cases which showed similarly drooping canal walls recovered without operation, this sign persisting to the last. While there may have been a certain degree of mastoiditis which healed, it certainly was not a marked suppuration.

The course of this disease at first showed a very acute hyperemia of the middle ear, of sudden onset, with redness, bulging and vesicular formation on the membrana tympani. This soon became cellulitis, with an acute hyperplasia of the mucous membrane. The same course of events proceeded in varying degree into the mastoid cells, although not evidenced by subjective symptoms, being only shown by the X-ray findings. There was a serosanguineous discharge, redness and swelling of the upper portion of the drum, obliteration of the superior angle of the canal, and protrusion of the mucous membrane of the middle ear through openings in the membrana tympani. This was mainly an epitympanic involvement because of the anatomy of the epitympanum. Further extension resulted in the flattening and drooping of the superior and supero-posterior canal wall.

The original infecting organism, whatever it was, was not suppurative in its action and pus formation did not occur until we had a secondary infection, following a breaking down in the protective qualities of the mucosa. This was presumably streptococcus. A purulent discharge now resulted but the drooping canal wall was independent of these, for this sign was seen in cases which never went on to a purulent discharge.

The picture at this stage was that of a true suppurative otitis media and one of two things took place. Either this subsided and the patient became convalescent in a varying degree of time, or the suppuration extended to the mastoid cells and resulted in true suppurative (operative) mastoiditis. This was evidenced sometimes by a bogginess of the membrana tympani and slight tenderness and edema over the mastoid, but most constantly by an increase in the amount of the discharge and the thickening of the mastoid periosteum, giving a velvety feeling on gentle palpation, especially upon comparison with the other presumable normal side. This stage was reached in from 8 to 15 days.

From this we may conclude that the signs indicative of operation for suppurative mastoiditis following influenza otitis media are: A history of otitis media with discharge for from eight days to three weeks, often quieting down and then starting up again; an increased discharge of purulent character; a thickened mastoid periostium and possible mastoid tenderness and edema and a boggy membrana tympani. The drooping superior canal wall is not reliable.

Some otologists take the view that every case of suppurative otitis media, going on for over three weeks, should be operated, if for no other purpose than to preserve hearing. This of course is of great importance, but we also must consider the length of time involved before putting men back to duty as effectuals. Some of these cases which ran on for longer than three weeks but which did not show the findings indicative of operation mentioned above, subsided and were discharged as cured from four to six weeks after the onset. Hearing upon discharge was considerably lowered but prognosis was good for improvement. Subsequent examination, in cases which were possible to follow, showed practically normal hearing in from two to three weeks after discharge from hospital.

In some hospitals the onset of the middle ear inflammation was not attended by the severe pain noted above; in fact, in several instances the otitis was not suspected until rupture of the membrane had taken place. Certain hospitals reported that while pain was noticed by the patients, it was not severe. The date of appearance of the ear complications in several hospitals was later than noted in the foregoing, many observers noting that the majority of these complications did not arise until about the tenth day of the disease.

The conclusion in the report just quoted relative to the drooping of the postero-superior wall of the external canal is not concurred in by many observers. The reports from other hospitals indicate that this sign was regarded as indicative of mastoid involvement.

The reports received from many hospitals contain much information of great interest relative to the aural complications of the influenza epidemic and extracts from certain of them are here quoted:

Base Hospital, Camp Sevier, S. C.[6]—Acute suppurative otitis media occurred in 43 cases. As compared with epistaxis this was a later complication, appearing in the majority of cases after the fifth day. Five of the cases came to mastoid operation. In many of the others, symptoms of mastoiditis were present but were not urgent and recovery took place without operation. * * *

In general it was observed in reference to otitis media cases: 1. The course, as a rule, was mild. 2. The onset of pain was sudden and the tympanic membrane showed most prominent bulging in the upper posterior segment. In many the most marked bulging was of Shrapnell's membrane.

Base Hospital, Fort Sill, Okla.[4]—Otitis media was relatively infrequent in this epidemic. About 1.1 per cent of all patients developed suppurative otitis media. The complication usually appeared during the first week of the disease. Bilateral involvement occurred in three cases. The presence of blebs in the auditory canal was very common. These also were frequently observed in the drum membrane. In most cases the drum membrane was promptly incised. The middle ear infection was not severe. The discharge usually ceased within a week or two.

Base Hospital, Camp Grant, Ill.[11]—There were over 600 cases observed with otitis media, acute, suppurative. In most cases there was a spontaneous rupture of the membrana tympani with, in a few hours, the onset of ear symptoms. The discharge, as a rule, appeared thick and purulent from onset and did not have the initial stage of a serosanguineous discharge so frequently met with

in the ordinary case of acute otitis media. Many of these cases were complicated by a diffuse otitis externa and very few showed any mastoid reaction. Most of the cases recovered rapidly; that is, in about a week.

General Hospital No. 2, Fort McHenry, Md.[12]—The small number of cases of middle ear involvement without serious ear complications is of special interest. A large number of ear drums were incised and following the incision a few drops of a serous or serosanguineous fluid would escape into the auditory canal and the drainage would continue for a few days, but the copious flow of the serous fluid from the middle ear in these cases was not seen in a single instance. We failed to see a true case of mastoiditis throughout the entire epidemic. Some showed a slight tenderness over the mastoid tips and a less amount over the antrum, but even with these symptoms they cleared up within an exceptionally short time and in these cases the impairment of hearing was so slight as not to be noticeable.

Base Hospital, Camp Travis, Tex.[13]—Otolaryngological work arising from an epidemic of influenza involving 11,059 patients from September 30, 1918, to January 1, 1919, showed only a nominal number of complications requiring special treatment. Acute otitis media necessitated myringotomies in a large number of cases and two mastoid cases were encountered. In all, the complications otolaryngologically from influenza were few and of no consequence in so far as complete recovery and return to duty were concerned.

Base Hospital, Camp Lewis, Wash.[14]—The amount of pathology found upon mastoid operation was variable but was in direct relation to the severity of the attack, the cases of simple influenza being milder than those in which bronchopneumonia existed alone or as a complication. They showed decidedly less destruction of bone.

In 20 cases dying from bronchopneumonia both mastoids were examined post-mortem. In five, one mastoid showed changes such as congestion, softening, milky or purulent fluid, while in three both mastoids showed similar changes. In but two of these cases was attention called to the ears prior to death, and in two the symptoms were extremely mild, patients complaining only of slight deafness or stuffiness.

Base Hospital, Camp Upton, N. Y.[15]—The number of acute otitis media cases was comparatively small, most of these being of a catarrhal rather than a purulent type, and many clearing up without paracentesis, while others were relieved by paracentesis and promptly cleared up after discharging a bloody serum for 24 hours. Nearly all of these cases were complicated by blebs on the drum and canal wall, a type that I had always been taught to regard as influenzal ears. Up to the present time no mastoids have come to operation as a result of the epidemic.

Base Hospital, Camp Hancock, Ga.[1]—As a result of the system of prompt notification of the department of all cases presenting ear symptoms, practically every case was seen in its earliest stages. If the ear drum was found to be normal in contour, the usual treatment was ordered. If the slightest amount of bulging was present the rule followed was to incise freely and at once. Each ward visiting surgeon carried with him the appliances for performing this little operation. There is no doubt that there may have been opened some middle ears which would have gone on to resolution without complications or sequelæ, but it is certain that there were no ear drums needing an incision that did not have one.

When an anesthetic was used, it was the usual mixture of equal parts of cocaine, phenol, and menthol. Sometimes it was effective and sometimes it was not. When the patient was very nervous and time would allow of it, an attempt was made to benumb the ear drum with this solution. Otherwise the drum was opened without an anesthetic.

The results of our plan of procedure can best be shown by reference to the figures for October, November, and December. The real epidemic began with an influx of patients on Sunday, September 29, 770 cases being admitted to the hospital on that day and during the night following.

During October many hundreds of ear cases were seen in bed and in clinic. On account of the hectic conditions under which everyone was working it is impossible to give the exact number. During November the number was smaller and during December it was smaller still.

In the three months there were 322 cases requiring myringotomy. In a few instances a second incision had to be made, and on still fewer a third. Of these cases 202 required incision of the ear drum in October, 89 in November, and 31 in December. Many of these developed tender mastoids. When the latter condition appeared a special endeavor was made to have the patient transferred to a ward where the routine treatment could be administered. The result was a most happy one, as not a single one of the October cases required a mastoid operation, report for that month reading: Myringotomies, 202; mastoidectomies, 0.

There were no cases of sinus thrombosis and none of otitic meningitis; in addition, none of the acute suppurative middle ear cases became chronic, every one ending in a dry ear and a healed perforation.

By the following month (November) the epidemic was on the wane, and the work of the department had lightened materially. The November report read as follows: Myringotomies, 89; mastoidectomies, 4.

Only two of these operations followed influenza, and both of them occurred in one soldier. This boy was a very septic specimen, with a negative Wassermann reaction. First (October 24, 1918) he developed a large external perichrondritic abscess of the thyroid cartilage, which was opened and drained. This was followed later (November 13, 1918) by a mastoid abscess of the left side, and still later (November 16, 1918) by the same condition on the right. Both of the other November mastoids were cases in which the middle ear became involved in the course of an acute coryza.

In December there were five mastoid operations performed and two of these were postinfluenzal. Of the others, two followed measles and one a coryza. The December report read as follows: Myringotomies, 31; mastoidectomies, 5. In this month the influenza incidence was very low, until about the middle of the month, when there was a slight recrudescence of the disease. The great majority of the ear cases in December developed in connection with either coryza, measles, or scarlet fever.

These figures, in the minds of the writers of this report, constitute rather a notable showing. The total admissions of influenza cases to the Base Hospital for the month of September–October [a] were 6,553. In November there were 1,162 and in December 66, making a total of 7,781. In addition to this, during those three months there were 426 admissions for measles and 418 for scarlet fever. Added to these there was a large number of cases admitted on account of ear or throat or nose conditions alone. From this large number resulted only eight cases requiring mastoid operation, one of these being bilateral, thus making nine operations in all. It might be added that all of them healed or are healing in the usual four to six weeks, with no complications or threatened sequelæ. One of them developed decided weakness of the facial muscles of the affected side, but shortly after the mastoid was cleared out the symmetry of the face returned to normal.

Hospital admissions.

Months.	Influenza.	Measles.	Scarlet fever.	Myringotomies.	Mastoid operations.
September–October [b]	6,553	145	6	202	0
November	1,162	215	401	89	4
December	66	65	11	31	5
Total	7,781	426	418	322	9

Mastoid operations.

Months.	Postinfluenzal.	Postmeasles.	Postscarlet.	Postcoryza.	Total.
September–October [b]	0	0	0	0	0
November	2	0	0	2	4
December	2	2	0	1	5
Total	4	2	0	3	9

Embarkation Hospital, Camp Stuart, Va.[16]—The proportion of ear, nose, and throat complications at this hospital was not nearly as great as at some camps throughout the country. This was probably due to the low incidence of streptococcus hemolyticus occurring during the epidemic at this post. The predominating causative factor was found to be the pneumococcus group IV, and streptococcus viridans—both organisms of comparatively low virulence—instead of the deadly

[a] Includes September 29 and 30.

[b] From September 29 to October 31, inclusive.

hemolyticus, which was present in the majority of influenza cases and in the ear, nose, and throat, complications of these cases. In a total of some six thousand cases of influenza, the department was called to see only forty cases of otitis media, acute catarrhal and suppurative, and thirty-five cases of sinusitis, the latter of catarrhal type and confined almost entirely to the frontal sinus. A rather remarkable feature of the epidemic at this hospital was the fact that none of the cases of otitis media developed mastoid disease. This was probably due to the absence of streptococcus hemolyticus and to the low virulence of the invading organism.

Base Hospital, Camp Shelby, Miss.[17]—There have been unusually few complications of the ear, nose, and throat associated with the influenza epidemic. This is accounted for by the fact that the patients were immediately hospitalized as soon as they became ill and complications received prompt attention before they became severe. There were only four mastoid cases which could be definitely referred to the influenza epidemic. There were quite a few otitis media cases which cleared up after prompt incision of the drum. There were also a few sinusitis cases which responded to nonoperative treatment, but on the whole, the ear, nose, and throat complications were very few.

Base Hospital, Camp Taylor, Ky.[9]—More than 2,000 cases of otitis media developed during the six weeks of the epidemic. Drum incisions were done as early as possible in all cases. Otitis media usually developed very rapidly. Frequently there was less than an hour between the onset of pain and rupture of the drum membrane. As a result quite a few cases came to us with an ear which had been discharging for some time. Fewer complications and quicker healings were had in the cases seen early and where drum incision was made.

The picture of the influenza otitis was one of a full feeling in the ear, with a sudden onset of sharp pain which usually continued until the drum was opened. Examination revealed a very red, thickened drum membrane, usually very much distended. On opening the membrane there exuded a thin bloody serum and at times a decided hemorrhage occurred. Cultures were taken from all ears; those showing the influenza bacillus alone usually healed in a few days; those showing staphylococcus followed the usual course of acute suppurative otitis. The cases with hemolytic streptococcus infection were characterized by a very profuse, thin, seropurulent discharge. The majority of these cases developed mastoiditis.

Cultures from the pus of discharging ears and mastoids showed markedly different results. Many were negative. When the cultures were positive the prevailing organisms were the staphylococcus, pneumococcus, and streptococcus. In only a few cases was the influenza bacillus isolated. The hemolytic streptococcus was reported as present in a number of cases and these constituted the most severe ones and those most frequently complicated with mastoiditis. The reports from most hospitals show a marked uniformity in this respect.

The statistics compiled in the Office of the Surgeon General from the report cards of sick and wounded show that for the period from April 1, 1917, to December 31, 1919, 734,397 enlisted men were admitted to sick report in the United States and Europe with the diagnosis of influenza.[18] From the same source the following table of complications pertaining to the ear, nose, and throat, is compiled from the cases admitted for influenza.

TABLE 19.—*Otolaryngological complications of influenza, United States and Europe, April 1, 1917, to December 31, 1919, inclusive.*

	Number of cases.	Deaths.		Number of cases.	Deaths.
Rhinitis	1,023	14	Sinusitis	1,023	14
Pharyngitis	678	8	Otitis externa	48	
Tonsilitis, acute	2,617	26	Otitis media	3,923	122
Laryngitis	490	8	Mastoiditis	566	18

It is not believed that the above figures represent the correct number of complications which occurred. The true number must have been in excess of those given, but presumably many were omitted from the sick and wounded cards for various reasons. The deaths noted can not be assumed to have occurred by reason of the complication given, as many of the deaths were unquestionably related to the original admission or a pulmonary complication rather than to the otolaryngological condition noted.

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SECTION VI.

OTOLARYNGOLOGY IN THE AMERICAN EXPEDITIONARY FORCES.

INTRODUCTION.

The importance of a thoroughly trained and well-equipped otolaryngological service in the medical department of an army during war was demonstrated during the World War. The general character of the warfare, the extensive use of artillery, and the powerful explosives employed, all combined to produce a greater number of injuries to the head and face than had been encountered in any previous war. The inevitable result of so large a number of head injuries was extensive involvement of the nose, the accessory sinuses, the ear, the mastoid, and other anatomical regions which are generally regarded as the special fields of the otolaryngologist. While the primary treatment of battle wounds of every character usually was conducted by the general surgeons on duty as operating surgeons with the mobile and evacuation hospitals, the later care of cases of the class mentioned above was best carried on by the otolaryngological specialists on duty at the base hospitals. Even at the front-line hospitals otolaryngologists, when available, were assigned to duty and acted as consultants, or, if their general operative experience warranted, as operating surgeons, especially on wounded patients whose injuries pertained to this specialty. In general the final results were believed more satisfactory when it was possible to have the skilled specialist perform the first operation on a wound of the nose, throat, or ear; but unless an otolaryngologist had a special surgical training he was found to be out of place as a member of an operating team.

In the consideration of diseases and wounds of the ear, nose, and throat the data presented have been selected from reports submitted by officers on duty in the ear, nose, and throat service of the Medical Department of the American Expeditionary Forces. These reports are with the records of the office of the chief surgeon, American Expeditionary Forces, now filed in the Office of The Adjutant General.

CHAPTER I.

ORGANIZATION OF THE OTOLARYNGOLOGICAL SERVICE.

The first of our otolaryngologists to arrive in France were with the base hospitals which were sent abroad at the beginning of our participation in the war. These officers, as a rule, had been selected by the medical directors of these hospitals; they were most capable, and were sufficient in number for the work then required of them. Later, with the arrival of additional troops, the demands made for the services of otolaryngologists showed that a shortage of these officers existed. Frequently the otolaryngological service of a hospital had only one medical officer assigned to it, although, as a rule, the bed capacity of the hospitals had been greatly increased. In some instances it was necessary for this officer to conduct the ophthalmological service as well.

When the final organization of the professional services of the Medical Department, American Expeditionary Forces, was completed an otolaryngologist was designated as senior consultant in ear, nose, and throat surgery. He immediately assumed supervision of the personnel assigned to this specialty and the general management of the professional attention to cases falling within its scope.[1]

A special otolaryngological service was organized in each base and evacuation hospital in charge, in each case, of a medical officer whose special training in civil life had been devoted to this specialty. Such assistants as were needed were assigned.

In each base hospital an examination and treatment room for otolaryngological cases was assigned and when necessary special wards for this class of cases were designated. Naturally the larger number of cases requiring otolaryngological care were of a type similar to that encountered in civil life, and this resulted in the institution of a large dispensary service at each base hospital.

It soon became apparent that there were being transferred from regiments to base hospitals many patients with diseases of the nose, throat, and ear whose condition did not require hospitalization, and whose absence from their organizations materially and unnecessarily reduced the fighting strength of these units. To obviate this loss skilled otolaryngologists were assigned to the divisions and it became their duty to inspect such patients before their transfer to a base hospital. This served greatly to reduce the number of patients with minor affections of the ear, nose, and throat transferred to the base hospitals.

In this connection the following letter was addressed by the senior consultant in otolaryngology to the chief surgeon, American Expeditionary Forces:[2]

JULY 15, 1918.

There is a general complaint in all base hospitals, both in the Zone of Advance and rear, that a large number of cases evacuated to them are already fit for line duty and have to be returned or sent to a depot for reclassification upon their arrival. This was especially emphasized at Base Hospital No. 9, where they said as many as 40 cases a week had been evacuated to them that needed no treatment whatever. Personal observation at one base hospital, No. 32, revealed the fact that in a convoy received the day the hospital was visited there were 60 otolaryngological patients,

58 of whom, after examination, were recommended to be returned to duty at once, as they required no treatment. It is suggested that opportunity be given for an examination of these patients by an officer assigned from the department prior to their proposed evacuation to base hospitals, in order that these men be returned to their organizations for duty without the usual delays consequent to evacuation and return to duty.

The nature of the duties of the otolaryngologists attached to the various mobile and evacuation hospitals varied according to the activities of the particular hospital. In order that a definite working plan for utilizing these officers might be available the following circular was issued to the commanding officers of evacuation and mobile hospitals by the headquarters of the medical and surgical consultants:[3]

With a view to expediting the care of soldiers with ear, nose, and throat injuries without interfering with the routine work of the surgical teams at mobile and evacuation hospitals, and also in order to keep the otolaryngologist assigned to these hospitals employed in a position where his services will be available when necessary, it is recommended that commanding officers of evacuation and mobile hospitals be directed to carry out the following:

(*a*) That the otolaryngologists who are appointed to mobile and evacuation hospitals be assigned as regular assistants on one of the permanent surgical teams, their duties to be those of regular surgical assistants except in cases of ear, nose, and throat wounds or injuries, when the chief of the team will in turn assist the otolaryngologist in the performance of the necessary ear, nose, and throat operations; (*b*) that the triage officer be instructed to direct patients with ear, nose, and throat injuries to this particular team for operation. When this team is not on duty, cases with ear, nose, and throat injuries alone should be sent to a ward and held for them. The same should apply to patients having other wounds in addition to the ear, nose, and throat injury except in cases of emergency.

These recommendations are made for the following reasons:

(*a*) Otolaryngologists attached to mobile and evacuation hospitals have as a rule no continuous work in their specialty and are frequently assigned to duty as ward surgeons, sanitary officers, mess officers, etc., in addition to their ear, nose, and throat work, and when an ear, nose, and throat case is sent to the operating room work is delayed until the otolaryngologist is found and while he prepares his instruments and himself for the operation; (*b*) the otolaryngologist in evacuation and mobile hospitals under the present arrangement is a supernumerary, having no operating-room table, assistant, nurse, or orderly assigned him, and interfering with the routine whenever an ear, nose, and throat operation is necessary.

An arrangement such as suggested above would also release one additional medical officer for other duties.

The following letter from the senior consultant, ear, nose, and throat surgery, to the chief consultant, surgical services, American Expeditionary Forces, was based on the result of inspections made of the various hospitals, and offered suggestions for the improvement of the otolaryngological service.[4]

A. P. O. 731, *July 31, 1918.*

From: Senior Consultant, Ear, Nose, and Throat Surgery, A. E. F.
To: Chief Consultant, Surgical Services, A. E. F.
Subject: Conditions ear, nose, and throat department since May 23, 1918.

1. First investigation showed in base and camp hospitals marked inequalities in personal fitness and material equipment of officers engaged in this department. In few cases was there a complete outfit of necessary instruments and in fewer cases the instruments required for functional examination of the hearing. Every effort has been made to overcome difficulties by moving personnel where the character and requirements of the service called for it, and advice has been given as to the requisition of much needed instruments and apparatus. There is also evident a lack of uniformity in the methods of testing the hearing and in the classification of cases for duty after the tests have been made. Many cases will have to be classified solely on the condition of the hearing, and the need for instruction of examiners, standardization of methods of investigation, and uniformity of classification is evident.

2. Many soldiers were found in base hospitals who had originally been withdrawn from active duty on account of minor acute inflammatory conditions of the ear, nose, and throat. The tendency of these conditions is to rapid cure, and it is proposed if possible to keep these cases under competent observation in the evacuation hospitals so that they may be returned directly to their organizations on recovery.

3. (*a*) The chief surgeon, A. E. F., has designated the Hotel Ruhl, Vichy, for the establishment of a special central hospital for the treatment of cases belonging to the eye, ear, nose, and throat; facio-maxillary and cranio-spinal departments. The limit capacity of this building is about 1,200 beds, but this number can be indefinitely increased by the acquisition of buildings near by. The organization of this hospital is under way and some beds are already reported as ready for occupancy. The proportion of beds for this department should be about 500 in the original building.

(*b*) In this center it is proposed immediately to start classes for instruction in the functional examination of the hearing and of the vestibular apparatus. Uniformity of methods of examination and classification for return to duty will be established and such other instruction can be added as circumstances demand.

(*c*) The future of the service will undoubtedly require the establishment of similar subsidiary centers in the neighborhood of large hospital groups.

4. The most urgent needs of the service now are:

(*a*) Complete outfit of operative instruments (see inclosure I).

(*b*) Complete outfit of instruments for testing hearing (see inclosure II).

(*c*) Rotation chairs in all base hospitals.

(*d*) Systematic instruction of all officers in this department in functional examination of the vestibular apparatus (see par. 3).

With the constant growth in strength of the American Expeditionary Forces the necessity of more careful supervision of the otolaryngological service became apparent and certain experienced otolaryngologists were therefore assigned to duty as consultants to the senior consultant.[1]

In addition, consultants for ear, nose, and throat surgery were now assigned to the armies and corps which had been organized and to the various hospital centers. The duties of these officers were outlined in Circular No. 57, Chief Surgeon's Office, American Expeditionary Forces, which is quoted in the introduction to the section of this volume relating to ophthalmology in the American Expeditionary Forces. (See p. 668.)

At the suggestion of the director of professional services, a circular was prepared by the senior consultant setting forth the routine treatment considered advisable for the lesions of the ear, nose, and throat most frequently seen. This circular was as follows:[2]

CONDENSED SCHEDULE OF TREATMENT FOR EAR, NOSE, AND THROAT CASES.

Prevention of head colds.—Belladona, gr. 1/10; camphor, gr. 1; quinine bisulphate, gr. 1; ammonia muriate, gr. 2; powdered opium, gr. 1/20. Can be given either in capsules or powder, one every hour for three doses and then every three hours.

Tubal catarrh.—Inflation and vaporization of tube and middle ear through catheter, followed by local application of 2 per cent silver nitrate to pharyngeal end of tube.

Acute Otitis, incipient stage.—Frequent hot irrigations followed by dry external heat. When drum membrane is bulging, free incision in posterior, inferior quadrant extending into Shrapnell's membrane, followed by frequent warm irrigations of normal salt solution or boric acid.

Furunculosis; incipient stage.—External canal packed loosely with cotton saturated with a 30 per cent solution of argyrol and renew every four hours. If not obtainable, apply zinc oxide ointment every six hours. If swelling persists, free incision followed by hot saline dressings. When recurrent and multiple, use vaccines, preferably autogenous. Can be obtained at central laboratory.

Mastoiditis.—Nonoperative: Treatment of acute otitis as above. Observation period limited to few days.

Operative mastoiditis: Removal of diseased bone. Establish free drainage between mastoid cavity and middle ear. Close superior angle of wound with suture and treat cavity as open wound by packing with gauze.

Sinus thrombosis.—Substantiate by blood culture where possible. Uncover sinus from above angle or knee well downward toward bulb. If parietal or organized clot, evacuate, pack, and treat as open wound. If clot broken down and pus present, treat as above and in addition ligate and resect internal jugular vein from clavicle to point above facial vein. Close neck wound and drain at lower angle.

Brain abscess.—When suspected, search for path of infection, first through roof of mastoid antrum, second through tegmen tympani, third cerebellum posterior to sinus. Free exposure by bone removal. Incise dura through which pass sutures. Explore brain tissue with long, narrow-bladed knife. If abscess found, gentle irrigation with warm, normal salt solution through drainage tube or catheter and introduction of drainage tube to lowest point of cavity. If negative, close dura with sutures already in position. Where possible, notify consultant of suspected case before operating.

Nose.—Where deviation of septum is sufficient to obstruct respiration, a submucous resection should be done, otherwise let alone. Accessory sinus. Acute involvement. Shrinking of tissue, suction, inhalations, and warm irrigations followed by sprays. Remove middle turbinate if necessary to establish drainage, with pus discharging, open and drain. In fractures, reset at once if possible and maintain position by splints. Preserve all bone splinters and cartilage that have periosteal attachment.

Lacerated wounds.—Excision of traumatized tissue with primary suture where possible.

Pharynx.—Acute tonsillitis: Frequent hot saline gargles. Medication, sodium salicylate. Tonsils to be removed only when markedly hypertrophic or diseased, and then by method producing a minimum of trauma. No tonsils to be removed during an acute inflammatory process. In all mucous membrane irritations due to gas, local applications of limewater or bicarbonate of soda, followed by a spray of camphor and menthol, of each 20 gr., in 4 ounces of liquid albolene or oil.

Adenoids: When causing an obstruction, to be removed.

Peritonsillar abscess: Free incision and drainage.

Larynx.—In acute conditions, warm inhalations, sprays, cold compresses external, in gas cases. Primary application of limewater when possible, otherwise solution of bicarbonate of soda. With hemorrhage, ulcerations, and erosions, applications of guaiacol 2 per cent, camphor and menthol 4 per cent, in liquid albolene or boiled linseed oil. If lesion extend into trachea, above application by means of laryngeal syringe.

Laryngeal edema.—External applications of ice when obtainable. Spray of adrenalin, lemon juice, following in half an hour by deep pharyngeal irrigations of hot saline solutions, 2 or 3 quarts at each sitting.

Trachea and pharanyx.—Foreign bodies. Pharyngoscopy and removal.

External wounds of ear.—Débridement of traumatized tissue. Approximate surface with primary suture wherever possible. Reconstructive work to follow later. Type of operation and flap needed depending on existing conditions, to be followed by skin grafting when required.

Ear protectors.—Cotton or waste saturated in vaseline oil, wax, or tallow. Avoid those made of celluloid. Object of protectors, first, to prevent concussion; second, to maintain a maximum of hearing when worn.

SPECIAL HEAD HOSPITAL.

Base Hospital No. 115, known as the Special Head Hospital, arrived in France on September 2, 1918, and immediately began functioning at Vichy.[5] After this hospital had been located and was functioning efforts were made to route important ear, nose, and throat cases to the Vichy Center. The following extract from a general circular sent out from the office of the chief surgeon at that time is of interest:[6]

Circular No. 50.

1. Instruction regarding hospitalization and the evacuation of patients with disease or injury of the eye, ear, nose, throat, and maxillofacial region.

In general, the policy as regards hospitalization and evacuation of these cases is as follows:

(*a*) Simple cases should, whenever possible, be retained for treatment with their organization or be treated in near-by camp, field, or evacuation hospitals.

(*b*) Cases not suitable to be retained with organizations but which will be fit for return to duty in the A. E. F. within a reasonable time should be transferred to the nearest camp or base hospital.

(*c*) Cases which are permanently unfit for duty in the A. E. F., or which will require prolonged treatment to render them fit for duty, should be classified as D and evacuated as soon as safely transportable to the United States. Class D cases in which healing might be materially retarded by delay or interruption of treatment incident to evacuation to the United States, or which have unsightly wounds of the face and neck that could be materially helped within a reasonable time, should be retained for primary treatment in the A. E. F. The treatment of cases retained in France must involve the least possible amount of transportation from one hospital to another, and facilities will be provided in each hospital center and in the larger base hospitals not connected with hospital centers for the treatment of this class of cases. Base Hospital No. 115, located at Vichy, has more elaborate equipment for this class of patients. Consultants in the different specialties will be located in special hospitals, whose services can be called upon by neighboring hospitals. Address where those consultants can be reached will be published from time to time.

It was also planned to use Base Hospital No. 115 as a center of instruction for officers who needed practical training in caring for battle casualties that required reconstructive work along eye, ear, nose, throat, and facial-maxillary lines, and many officers were assigned here for this type of instruction, as well as to become familiar with methods of routine functional examinations of the ear. Although this hospital functioned but a comparatively short time prior to the armistice, the work it accomplished more than justified its being chosen as a special center.

REFERENCES.

(1) G. O. No. 88, G. H. Q., A. E. F., June 6, 1918.

(2) Letter from the Senior Consultant in Otolaryngology to the Chief Surgeon, A. E. F., July 15, 1918. Subject: Examination of patients by otolaryngologists. On file, Organization Records Division, A. G. O., Medical Department Records, Chief Surgeon's Files, 321.6242 (Otolaryngology).

(3) Letter, July 15, 1918, in Report from the Senior Consultant in Ear, Nose, and Throat Surgery, A. E. F. On file, Historical Division, S. G. O.

(4) Letter from the Senior Consultant in Ear, Nose, and Throat Surgery, A. E. F., to Chief Consultant, Surgical Services, A. E. F., July 31, 1918. Subject: Conditions Ear, Nose, and Throat Department since May 23, 1918. On file, Historical Division, S. G. O.

(5) Historical Report of Base Hospital No. 115. On file, Historical Division, S. G. O.

(6) Circular No. 50. Chief Surgeon's Office, A. E. F., October 4, 1918. Subject: Instructions Regarding Hospitalization and Evacuation of Patients with Disease or Injury of the Eye, Ear, Nose, Throat, and Maxillofacial Region. On file, Historical Division, S. G. O.

CHAPTER II.

DISEASES OF THE EAR, NOSE, AND THROAT.

CHRONIC DISEASES.

One outstanding feature of the otolaryngological service of the American Expeditionary Forces was the large number of chronic diseases of the ear, nose, and throat which required either hospitalization or prolonged dispensary treatment. These conditions, in the majority of cases, had existed for many years, certainly long prior to the time of entering the military service. The lowered standards of physical requirements for entrance into the Army, which were adopted with the onset of the selective service method of procuring soldiers, were responsible for the acceptance of many substandard men. However, unquestionably many men who were passed by the examining medical officers, had defects of the character noted which were sufficient to have warranted their rejection. The hurried manner in which the physical examination of large bodies of men was necessarily conducted accounted in large measure for the defects in question being overlooked.

A very large number of soldiers were found to be the victims of a unilateral or bilateral chronic purulent otitis media with markedly diminished hearing on one or both sides. Many others suffered from unilateral and bilateral chronic catarrhal otitis media with loss of hearing to such an extent that had they developed a complicating acute lesion they would have been practically useless for active duty of any kind. There was also a considerable number of men who showed on physical and functional examination, a rapidly developing otosclerosis. In others who complained of vertigo, tinnitus, and diminished hearing there were found upon examination single and multiple exostoses of the external auditory canal. These growths had advanced to such an extent in many of the cases that a view of the drum membrane could not be obtained. In still another group many were discovered in whom there was complete loss of audition on one side, the labyrinth being entirely out of commission. In the fall of 1917, when cold weather set in, soldiers suffering from these various types of aural disease applied in large numbers for care and treatment at the dispensaries and base hospitals. In many of these hospitals an attempt was made to classify these men and recommendations were made that many of them be utilized in the future for duty with labor battalions and at bases in the rear rather than be allowed to return for front-line duty; only a limited number retained sufficient audition to make them available for guard duty. Of the cases of purulent otitis media seen at this time, 10 per cent showed the presence of polyps and 20 per cent of the entire number seen disclosed the presence of granulation tissue in the middle ear cavity.

APPROXIMATE HEARING STANDARDS.

During the first part of the war there were frequent requests from the various hospitals that a standard of hearing be fixed that would assist the officers in local charge in determining the degree of impaired audition which was essential to different classes of duty so as to aid them in the future disposition of the patients—whether they should be returned for active or for special duty, or should be ordered before a medical board for ultimate disposition. A working schedule for the classification and standardization of ear cases was submitted to the chief surgeon in the belief that this would simplify the work in the otolaryngological department as well as aid the disability boards in classifying the cases that must come untimately before them.

A tentative schedule with approximate hearing standards was submitted to the following effect:[1]

I. Hearing tests must be made for each ear separately, using the noise apparatus when necessary.

II. All reports of the functional examination of the hearing must show at least:

(*a*) Hearing distance for the whisper or conversational voice.

(*b*) The lower tone limit.

(*c*) The upper tone limit (Galton whistle).

(*d*) The absolute bone conduction.

The following simple scheme is suggested for report:

RIGHT EAR.		LEFT EAR.
....	Acoumeter	....
....	Whisper	....
....	Voice	....
....	Lower tone limit	....
....	Upper tone limit	....
....	Bone conduction	....
....	Rinne	....
....	Weber	....
....	Gellé	....

III. The report will show clearly the amount of variation of bone conduction; thus, bone conduction (left ear, diminished one-half, two-thirds, etc.).

The following rough tables suggest the disposition of cases showing loss of hearing, it being granted that the hearing distance for conversational tones under favorable conditions is approximately forty feet:

IV. 1. Nonsuppurative, nonprogressive cases:

(*a*) One ear normal; other ear, hearing diminished up to 50 per cent. Return to duty.

(*b*) One ear normal; other ear, hearing diminished above 50 per cent. Any duty except guard duty in front line.

(*c*) Hearing diminished both ears up to 50 per cent. Any duty except guard duty.

(*d*) Hearing diminished both ears above 50 per cent. Usefulness as soldier to be determined by exact degree of loss of hearing and physical and mental fitness otherwise.

V. 2. Suppurative cases:

(*a*) Treatment of acute and chronic discharging ears should be under the direction of the medical officer concerned. The usefulness of the soldier in chronic suppurative cases will depend largely upon the amount of loss of hearing and will be in accordance with the tables for nonsuppurative cases. Operations for the cure of discharge are not generally recommended for soldiers in active service, in the absence of complications.

VI. All cases showing 75 per cent or greater loss of hearing should be brought before a medical board for ultimate determination.

VII. All opinions as to status of soldiers with impaired hearing will be modified when symptoms referable to the vestibular apparatus are also apparent.

Hdq. Medical and surgical consultants, A. E. F., A. P. O. 731.

AURAL COMPLICATIONS OF THE INFECTIOUS DISEASES.

MEASLES.

During the winter of 1917 and 1918 aural complications of measles were numerous and consisted largely of a purulent type of infection which resulted in a large number of mastoid involvements, the predominating infection being the streptococcus hemolyticus. Several measles cases in addition to the mastoid sequelæ developed an infection of the sigmoid sinus and internal jugular vein. A number of the sinus cases in which a jugular ligation below the facial vein was done resulted fatally, as septic material was being constantly introduced through this port of entry, this resulting in a continuation of the pyemic conditions. These fatal cases in a number of instances were due to inexperienced operators who did not ligate and resect the internal jugular vein above the facial tributary.

SCARLET FEVER.

Only a few aural infections developed as a result of this disease, and they were of the acute purulent variety without complications.

TONSILLITIS.

A few cases of acute purulent otitis media developed as a complication of the acute follicular and peritonsillar varieties of tonsillar inflammation. In only a few cases was there an extension of the disease to the mastoid process, and almost invariably the infection when it did so extend was found to be due to the streptococcus mucosus capsulatus.

MUMPS.

During the extensive epidemic of mumps in the winter of 1918 there were comparatively few aural complications, acute catarrhal otitis media occurring most frequently. Only three cases of labyrinthine involvement with unilateral deafness were reported.

CEREBROSPINAL MENINGITIS.

During the epidemic of cerebrospinal meningitis that occurred in the late fall of 1917 there were many aural complications—acute catarrhal, acute purulent, and labyrinthine of the hemorrhagic variety. Of the latter type there was but little time for study and observation, as many of the men lived but a few hours after they were first seen. Autopsy reports in the cases in which the labyrinth was involved invariably showed upon sections of the temporal bone that an extensive hemorrhage had occurred in this region.

PNEUMONIA.

Many aural complications of the acute purulent variety developed as sequelæ of pneumonia, and in about 5 per cent of these cases there was a mastoid involvement complicating the ear condition.

INFLUENZA.

During the 1917 and 1918 epidemics of influenza there were but few aural complications, owing largely to the active treatment instituted at the onset of the disease. The cases of influenza, where possible, were isolated in barracks or hospital wards and were treated with warm nasopharyngeal irrigations of saline and sodium bicarbonate three times a day, using from a pint to a pint and a half of the solution at each sitting. The air in the wards was kept constantly permeated with vapor composed of the following: Menthol, gr. 30; camphor, gr. 40; compound tincture of benzoin, oz. 4; 2 drachms to quart of boiling water.

Where possible direct inhalations were given, but when, as frequently happened, this could not be done, large receptacles of water kept at the boiling point and containing the above solutions were placed in the wards. In this way the patients were constantly breathing in a moist, medicated atmosphere. When the cough was especially troublesome, a few drops of chloroform were added to the mixture. In some of the hospitals inhalation rooms were arranged for ambulatory patients, the arrangement for inhalation being a long metal tube with openings fitted with a nose and mouth piece at regular intervals. This tube extended the entire length of the room on one side, then was carried to the opposite side, running parallel until it returned to join a main tube supplying both inhalation tubes. This main tube led up from a covered reservoir filled with boiling water. Creosote was frequently used in the water to take the place of the mixture previously mentioned. At times only the compound tincture of benzoin was available for use in the water.

OTITIS EXTERNA.

From time to time, especially in the spring of 1918, many cases of furunculosis of the external auditory canal developed. If seen during the early stage, gauze soaked in a 30 per cent solution of argyrol and gently packed, in the canal with renewal every four hours usually sufficed. If argyrol could not be obtained the affected auditory canal was filled with warm zinc oxide ointment and this was renewed every six hours. If the condition was well developed when first observed and evidence of pointing presented, a free incision was made to the bone, a drain inserted, and the whole ear, mastoid, and side of the head, was enveloped in a gauze dressing saturated with the hot saline solution and this was reapplied every four hours. In a few of the cases seen there were recurring attacks despite every care and treatment. For these a mixed staphylococcus and streptococcus vaccine was obtained from the central laboratory and good results followed its use. In all cases of furunculosis except those induced by injuries, iron, arsenic, and strychnine administered internally were valuable aids to speedy convalescence.

TUBAL CATARRH.

During the fall and early winter of 1917 a very large number of soldiers in the training areas, owing to the cold and imperfect housing conditions, developed an acute catarrhal inflammation of the Eustachian tubes, resulting in tinnitus and partial temporary deafness. It was necessary to hospitalize many of these men so they could obtain frequent treatment. Vaporization of the Eustachian tubes through the catheter once or twice a day, followed by the ap-

plication of a 2 per cent solution of silver nitrate to the pharyngeal end of the tube, with a menthol and camphor spray in oil and a hot saline gargle used frequently, was all that was required, and these men were returned to duty cured, in from two to five days. Scarcely a case if seen early and treated in this way developed a middle ear infection.

ACCESSORY SINUSES.

During the autumn and winter of 1917 and the spring of 1918 a large number of soldiers in the hospitals suffered from a single or multiple acute nasal accessory sinus disease. The treatment of these conditions was by shrinkage of the swollen mucous membrane, suction, and the application of a mild astringent followed by the use of hot vapor inhalations and a warm oil spray to the nose and the application of dry external heat over the sinus. Occasionally the maxillary antrum had to be aspirated and washed out or one of the other sinuses had to be drained. Frequently an etiological factor in producing these complications was a permanent hypertrophy of the turbinal tissue or a markedly deflected septum. Where these acted as causative factors they were operated on before the patient was returned to duty after the subsidence of the acute attack. In none of the cases coming under our observation was it necessary to do a radical operation upon any of the sinuses.

VINCENT'S ANGINA.

In the fall of 1917 an epidemic of sore throat developed among the marines stationed at Bordeaux. Its onset was sudden and the symptoms very acute. Shortly after its outbreak over 600 men were hospitalized and many more were incapacitated. Cultures from the throat were taken and all were positive, showing the presence of true Vincent's angina. During the succeeding winter and spring there were epidemics of this disease in all the camps and training areas, necessitating the use of a large number of beds in the hospitals adjacent to these areas, one hospital in particular having under treatment at one time over 700 cases. During all the time that our troops were in France this disease was more or less prevalent and all medical officers were advised to have cultures taken at the onset of a sore throat to determine the cause of the existing infection. There were but few sequelæ and these were of little importance. The prognosis was invariably good.

The treatment consisted in isolation and the application to the affected mucous membrane of fused chromic acid crystals generously applied to the inflamed surface, followed in three hours with a hot saline gargle frequently repeated. Usually two applications of the chromic acid at 24 to 36 hours intervals were all that was needed to destroy the germ producing this infection. Cultures taken two, four, and six days after this treatment proved negative. In some of the more isolated hospitals and camps salvarsan was used as a local application daily for several days. This treatment was reported as efficacious but when it was employed the convalescence was prolonged and repeated cultures showed the presence of a true Vincent's spirillum for a much longer period than when chromic acid was applied.

REFERENCE.

(1) Report from Senior Consultant, Ear, Nose, and Throat Surgery, A. E. F. On file, Historical Division, S. G. O.

CHAPTER III.

BATTLE INJURIES OF THE EAR, NOSE, AND THROAT.

The cardinal principle of front line work in the otolaryngological department, following the example of the general surgeon, was the excision of all devitalized tissue and the removal of all loose bone splinters and foreign bodies. Through-and-through penetrating wounds were closed primarily. In all cases in which wounds were open and there was a tendency to contraction of the tissue, with increased separation of the edges, a primary suture was done in order to obtain a better cosmetic result for the reconstructive work that was to follow. In penetrating wounds of the anterior wall of the antrum, no matter how produced, counterdrainage was instituted from below. In bullet and shell wounds of the nose, where the bones were shattered, excision followed by the removal of the loose splinters was the rule, but in no instance was there removal of any piece of bone or cartilage to which there was still an attachment of periosteum. These pieces were approximated as accurately as possible and held in place by some mechanical device so as to allow for nature's repair. In this way much bony structure of the nose was preserved so that the reconstructive work was made easier and the final result obtained more satisfactory. All shell and bullet wounds of the auricle were treated by primary suture wherever possible.

Impacted shell fragments in the external auditory canal were removed and the resultant wound treated by the open method in order to promote drainage, and later, when necessary, plastic procedures were instituted. In shell and bullet wounds of the mastoid process removal and open treatment was the rule. In penetrating wounds of the skull that had produced injury of the nose or ear and their adjacent structures a débridement was all that was indicated at first. Later, when the X ray had localized the foreign body and the patient's condition permitted, an attempt at removal was made. An additional help in these cases was the Hirtz compass. No instrument gave as much help as did this by its precision and accuracy. In no brain case was it permissible to further mutilate the brain tissue by digital exploration. If the foreign body could not be removed by a continuous flow of a warm saline solution or other nonirritating fluid through rubber tubing, or could not be extracted by aid of forceps, it was left alone, as experience soon taught that many of these cases recovered by letting the foreign body remain in situ. Where fracture of the skull occurred all depressed areas of the bone were removed. At first a mistake was made by removing too small an area. Experience taught the error of this, as subsequent hernias were far less liable to occur when a large amount of bone was removed. This was probably due to the fact that a large exposure produced a minimum amount of pressure from within, whereas a small opening made for a maximum of pressure. In all wounds of the throat and mouth the principles of general surgery were carried out, always keeping in mind that drainage was an important factor.

In reconstructive work on the auricle, where the greater portion had been destroyed, a more satisfactory result was obtained by making a cast or a

mold, and from this constructing an artificial auricle from what was known as Hemming's paste rather than by doing a plastic operation. These artificial ears were easy to place in position, were held by spirit cement, and were made to conform in color to any skin. They could be removed easily and replaced by the patient at any time. Artificial noses were made in the same way. In some of the nasal injuries it was necessary for respiratory as well as cosmetic purposes to loosen all adhesions and to elevate as much as possible by inserting a piece of cartilage or bone to replace in a measure the tissue destroyed by the trauma. In many cases it was found advisable to work on these patients in conjunction with dental surgeons. If appliances had to be fitted and incidental details worked out, much better results were obtained through the help of some one who had been specially trained in devising, making, and fitting such appliances. In the reconstructive work no didactic rules could be laid down, as the procedure depended entirely upon the size, location, shape, and condition of the wound and amount of tissue that was available for repair. Much less reconstructive work was done in France than was at first expected. This was owing to a decision made by the chief surgeon to return all soldiers to the United States who could not be made ready for line duty within a period of from three to four months or less.

NASAL INJURIES.

These varied from slight contusions to partial or complete destruction of both the soft and bony framework of the nose. In lacerated wounds excision of the traumatized tissue was limited as much as possible and was followed by primary suture. Where there was extensive bony destruction and loss of the soft parts, all loose bone splinters were removed but all the framework of the nose that could possibly be conserved was left intact. Splinters of bone and segments of cartilage that were loose but still retained periosteal attachment were preserved in an effort to build up a serviceable framework that would later serve as a base for reconstructive work. In cases in which the soft parts had been badly damaged or totally destroyed, retention sutures were introduced as early as possible to prevent an excess of contraction and to cover as much as possible of the bones and cavity beneath. Mechanical appliances, often most ingeniously devised, were used as splints to retain position and contour. When the meatus was injured on one or both sides, large soft-rubber tubes were introduced to maintain patency, and all available tissues was utilized in an effort to repair, in a measure, the damage that had been sustained. Such patients were sent to one of the bases for further reparative work. Occasionally a bullet would shatter the bones of the nose, be diverted in its course, traverse the maxillary antrum of the opposite side, and make its exit through the cheek or jaw. These cases were treated in the usual manner; in addition, drainage was established through the antral floor as well as between the antrum and the nasal cavity of the same side. In two instances, in wounds of a similar character, the bullets were found in the antrum loose and free of bone impaction.

Shell and shrapnel wounds of the nose were not uncommon and produced very extensive destruction of both the soft and bony parts. A fairly large number of such cases were immediately fatal, owing to a fragment lodging in the base of the brain; the majority of such fragments traveled a horizontal

course to the base. In a few cases seen the missiles had continued upward, causing extensive destruction of one or both frontal lobes. Men suffering from wounds of this character who survived removal to the evacuation hospitals were operated upon at once, provided they were not in shock. The operative procedure which followed the taking of a radiograph to determine the situation, size, and shape of the foreign body was to attempt removal at first with the forceps. In the cases where the foreign body was not deeply imbedded frequently this could be done, but where the missile was deeply placed it was in some instances exceedingly difficult to remove without injury to important structures. In some of these cases removal had to be effected through a counter-opening made some distance from where the foreign body was lodged and working carefully toward its site so as to avoid injury to other structures. When the shell fragment was reached it was removed with the forceps by a slow prying movement. This proved effective even though the fragment was quite firmly imbedded. In two cases where there was lodgment of an irregular fragment impacted in the base of the sphenoid bone it was necessary to remove the sharp angles of the fragment with a file before removal with the forceps could be accomplished. One of these patients survived for six days, meningitis being the direct cause of death. The other patient made an almost uninterrupted recovery, and when able to be removed was routed to a base hospital, where a plastic operation was done for the deformity that existed; an excellent result was obtained.

In several of the cases of extensive nasal wounds there was a complicating injury to the facial nerve in the region of the parotid gland. In six cases the nerve was completely severed—four by bullets and two by shrapnel. In all six cases there was active infection of the parotid gland when first seen and no reparative work for nerve restoration could be done. The cases that showed only a partial facial paralysis all occurred as the result of injury from shell fragments. In eight cases the main trunk of the nerve was the seat of injury, the point of injury varying from the exit of the nerve at the skull to where it entered the parotid. In several other cases terminal tributaries were injured.

Where only an injury to the main trunk and tributaries had taken place, patients, after the wounds had healed, were given treatment daily with the interrupted galvanic current, the positive pole being applied to the nape of the neck, and the negative to the main trunk of the nerve and its branches. This, with massage of the muscles of the affected area and the internal administration of strychnine, was usually sufficient to restore partial or complete function of the nerve, except in cases in which there had been a direct solution of continuity of the nerve trunk itself.

ACCESSORY SINUS WOUNDS.

In extensive nasal wounds it was frequently found that one or more of the accessory sinuses had been injured. In a few such cases every sinus was the seat of the injury. In these cases the treatment consisted primarily in removing the traumatized tissue and resultant débris; all other surgical effort was directed to preventing infection or to caring for it when it was present. The Carrel-Dakin solution proved valuable in the care of these cases.

It was observed that extensive wounds and injuries of the nose, accessory sinuses, and adjacent parts exhibited less reaction following either injury or operation, stood transport to bases better, and had a larger percentage of complete recoveries than ear injuries of a more or less similar nature.

EDEMA OF THE LARYNX.

This was occasionally met with in bullet or shrapnel wounds of the throat when one or both vocal cords had been injured. In nearly all of these cases it was necessary to do a low tracheotomy to save the patients from immediate death. Unfortunately, these cases could not be followed up, as those that survived, being incapacitated for further duty, were returned to the United States, most of them still wearing their tracheotomy tubes. Edema from gas inhalation, when the breathing was labored and shallow, was treated by adrenalin spray when obtainable. Later, a soothing application, such as guaiacol and camphor in oil, was used, followed by inhalations of a soothing character. In some of the very acute cases, where ice could be obtained, its application as a compress proved beneficial. In some of the more alarming cases, excellent results were secured by placing the patient with his head to one side and giving large and frequent hot saline irrigations through a long tube into the lower pharanyx until the alarming symptoms had subsided.

WOUNDS OF THE EXTERNAL EAR.

The number of battle injuries of the external ear and external auditory canal was greater than had been anticipated. Many of these wounds were accompanied by wounds of other parts of the head and face, and these often proved fatal when the brain or spinal cord was involved. Slight wounds of the auricle were easily treated by excising devitalized tissue, thorough cleansing, and primary suture, the sutures not being allowed to penetrate the cartilage.

If the external auditory meatus was involved, which was frequently the case, partial or complete occlusion, with impaired hearing, was the result. Many cases were seen in which the meatus was completely filled with shell fragments or shrapnel and these were usually complicated with a like impact in the mastoid region and with injuries to the face or cheek on the same side. In all the injuries of this type, both the fibrocartilaginous and the osseous meatus were involved. Nearly all of these cases were complicated by intracranial injuries of the severest type. In one, a shell fragment had penetrated the tympanic cavity, had passed through the inner table, had become deflected, and had lodged in the cerebellum of the wounded side. In this type of injury there was scarcely a case that did not show extensive tympanic destruction. These wounds were far more fatal when due to lateral impact of bullet or shell than were those in which the missile passed through the meatus and canal transversely. The treatment for the deep-seated foreign bodies was, first, examination by the X ray to determine location, size, and shape, followed by an attempt at removal. Many of the patients died in from twelve hours to four days after the operation. In the cases where the injury was less severe and recovery took place it was always followed by complete or partial atresia or stenosis. This was treated later by a plastic operation, followed by a skin graft to restore, in a measure, the mutilated meatus and canal.

WOUNDS OF THE TEMPORAL BONE.

As was the case with wounds of the external ear, gunshot injuries of the temporal bone were often associated with injuries of other parts and frequently proved fatal when the brain, spinal cord, or large blood vessels were involved. The cause of death in the majority of fatal cases was sepsis, which appeared in a comparatively short time. For this reason early operation was advocated in temporal bone cases, the best time for this being immediately after arrival at an evacuation hospital. The treatment of wounds of the temporal bone, however, came under the care of the general surgeon or of a specialist in neurosurgery, unless there was involvement of the mastoid cells. In the latter case it was regarded as desirable to have the necessary operation performed by an otologist, as he was especially familiar with this difficult region and with the adjacent structures. For operations in the mastoid region general surgical rules for wounds of the head were followed, namely: Excision of devitalized tissue; removal of all loose fragments of bone, pieces of clothing, hair, and bullet or shell fragments; arrest of hemorrhage, relief of compression of the brain if present; thorough cleansing of the wound, and establishment of proper drainage. Closure of these bone cavities by primary suture was never permitted. The great majority of mastoid wounds so treated made a good recovery.

INJURIES OF THE MEMBRANA TYMPANI AND TYMPANUM.

Prior to the World War traumatic injuries of the tympanic membrane in war had usually been associated with naval engagements rather than with land battles. The necessary proximity of men to the great guns, their stations in metal turrets, and the frequent concussions caused by projectiles striking the armor of ships, all contribute to ear disturbances in naval warfare. Due to the general use of high explosives during the late war, as well as to long exposure to rapid-fire machine guns in emplacements, rupture of the ear drum was the most frequent aural injury encountered in soldiers. While at times the drum rupture was the result of direct traumatism to the membrane or of concussion from a blow to any portion of the bony structure of the head the most common cause was the increase of atmospheric pressure produced by the detonation of a shell or bomb.

If the injured soldier was in a confined space, such as a dugout, or trench, both drum membranes were frequently ruptured. On the other hand, in the open, usually only one drum membrane was injured. If a sunken mine exploded in close proximity to the soldier it was almost the invariable rule to find both drums ruptured. In the majority of the cases the rupture took place in the inferior quadrant. The anterior segment of this quadrant was the one more frequently injured, probably on account of its proximity to the tympanic orifice of the Eustachian tube. The shape of the rupture varied from stellate, linear, angular, or transverse to quadrilateral. In a few of the cases certain portions of the drum had totally disappeared, leaving ragged, irregular edges, through which could be seen the bruised and swollen mucosa of the inner tympanic wall. Many times laceration of this mucosa was found, and occasionally a case was observed in which the malleolus had become dislocated by the violence to which the middle ear had been subjected.

It was the rule in all cases to inspect the external auditory canal, and if possible, to remove dried blood, cerumen, if present, and all débris by gentle manipulation with a cotton-tipped probe. If the foreign material could not be removed in this way, a warm saline solution was used as an irrigation to soften and remove it, after which a careful search for any further foreign bodies was made. The canal and ear were then wiped dry. Iodine, full strength, was applied, and a drying powder, such as boric acid, was plentifully insufflated over the entire area. Then a gauze wick, either plain or medicated, was introduced for drainage. In none of the subsequent dressings were solutions used, the field being merely cleansed with a cotton-tipped probe powdered, and the drain reintroduced. This treatment proved of far greater value than a treatment previously used, namely, frequent warm irrigations, for it was observed that where the moist treatment was employed suppuration was frequent and prolonged, while the dry method hastened repair and suppuration was rarely seen except in cases where complicating bone injuries were present.

INJURIES OF THE MIDDLE AND INTERNAL EAR.

All patients, who survived after sustaining a direct wound of the bony meatus, exhibited evidence of profound shock from the cerebral concussion produced by the injury in question. There was complete loss of consciousness, in many of the cases lasting for several days, and this was accompanied by marked neurological disturbances, central in origin. When such patients regained consciousness it was noticed with all that there was vomiting, vertigo nystagmus, and in some a palsy of the eighth nerve, together with more or less pronounced deafness. These symptoms, with the exception of the facial paralysis, gradually diminished as the patients improved, but when it came time for them to walk there was an unsteadiness and staggering gait present for several weeks. In nearly all such cases when facial paralysis was present it persisted.

The treatment of these cases following return to consciousness was almost entirely symptomatic. Strict rest and quiet in the recumbent position were ordered.

INJURIES OF THE EAR COMPLICATING FACIAL WOUNDS.

A bullet or projectile entering any part of the face might cause a lesion of the ear, and for this reason it was deemed advisable to have an otological examination made whenever facial injuries were encountered. Some cases proved fatal shortly after their reception at an evacuation hospital and before any surgical measures could be instituted for their relief. These were the ones with extensive brain mutilation. In cases of this class which were operated upon many died from meningitis. Several cases were seen in which there was rupture of the drum membrane, though the site of injury was remote from the ear; impaired audition was usually present in these cases. Deafness and tinnitus were observed also in a number where no lesions of the ear could be demonstrated. Most of these were unilateral but occasionally bilateral deafness was met with.

NERVE DEAFNESS.

This form of deafness was not infrequent and usually was found in patients who had suffered from profound shock. The majority were negative to ear and bone conduction and had no physical signs relating to the ears. In several there was a loss of voice and a disturbance of vision. Neurological examinations showed anesthetic areas, muscular tremors, paralysis, and an abnormal exaggeration of the reflexes. A large majority of these cases recovered under rest and symptomatic treatment. Some of the many aids which were used to hasten convalescence were suggestion by hypnotism, counter-shock, and stimulation by electricity. It was thought at first that some of these patients were malingerers but the application of otological tests disproved this belief, though a few of the patients simulating nerve deafness were found to be suffering from hysteria. There were two types, deafness and deaf-mutism. Nearly all these patients were curable by a process of reeducation and suggestion, which required only patience on the part of the otologist.

It was rare that complete and permanent loss of audition resulted as a sequel of so-called shell-shock per se. In many such cases there was temporary impairment of the hearing, both unilaterial and bilateral, but under neurological care the hearing in the majority improved without any aural treatment. In cases where there was complete and permanent loss of hearing it was found that this was usually associated with other injuries sustained at the time of the shock, or that in civilian life there had been a marked diminution in the hearing which had gone on for many years. A considerable number of patients claiming to be totally deaf were examined physically and functionally and it was demonstrated that all but three could hear. In one of these it was discovered later that 10 years prior to entering the service the man had met with an accident that had resulted in a labyrinthine hemorrhage, followed by complete deafness in the left ear. Much valuable information might have been gained from an early examination of these so-called shell-shock patients, but this proved impracticable and it was only after they reached the base hospitals on their return to the United States that the otologist had an opportunity to observe and study them.

VERTIGO.

Many cases of vertigo were observed in head wounds in which no aural lesion could be demonstrated. Babinski, it will be remembered, pointed out that no matter what part of the skull might be injured, it was possible to have a perturbation of the labyrinth producing vertigo. Testing the vestibular function frequently enabled one to locate the cause of the vertigo. In wounds of the occipital region, vertigo was especially common and was usually associated with an impairment of audition, either unilateral or bilateral. A frequent complication of wounds of the temporal bone was a lesion of the auditory apparatus on the same side. Several cases of a mild form of vertigo, seen from time to time, were caused by firmly impacted cerumen in the external auditory canal. No doubt this was due to water introduced into the canal when the soldier was bathing, this causing the cerumen to swell, thereby producing an excessive pressure on the membrane and on adjacent structures. Examination of certain men who complained of vertigo showed the exciting cause to

be a swollen Eustachian tube at the pharyngeal opening. These cases cleared up speedily under vaporization of the tube through the catheter followed by a mild stimulating application of silver nitrate to the swollen orifice of the tube. A toxic form of vertigo was occasionally met with, the patients exhibiting nausea, vomiting, tinnitus, a staggering gait, great prostration, and even syncope. This form of vertigo responded rapidly to rest, attention to diet, and the internal administration of hydrobromic acid, one-half dram, three times a day, diluted in water.

It was demonstrated that in all head injuries a complete physical and functional examination of the ear should be the rule in order to discover, at the outset, whether the auditory apparatus was or was not injured.

GAS POISONING.

As the treatment of all gas cases came first under the supervision of the chief consultant of the medical services, the otolaryngologist rarely saw such cases until they had been received in a base or other hospital for definitive treatment. This was usually several days after the inhalation of gas. Hemorrhages, erosions, and ulcerations of the mucous membrane of the nose and throat were then present, to a marked degree, in many cases. As all of these patients had received the preliminary alkaline treatment shortly after the gas was inhaled, the efforts of the otolaryngologists to relieve them consisted in applications of boiled linseed oil and other soothing remedies, with frequent inhalations of camphor, menthol, and compound tincture of benzoin in hot water. When the larynx was extensively involved an intralaryngeal application of the following solution was made with a syringe: Guaiacol, 2 per cent; camphor and menthol, of each 2 per cent in liquid albolene or boiled linseed oil.

This mixture applied to the larynx invariably gave relief, diminished the troublesome cough, lessened the pain, and frequently sleep would follow the treatment. In cases where the lesions were extensive these applications were made every four or five hours.

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